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Recognition of individual differences in the teaching of chemistry.

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RECOGNITION OF INDIVIDUAL DIFFERENCES IN THE TEACHING OF CHEMISTRY

Submitted by

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Sources

In conducting this study on the recognition of individual differences in the teaching of chemistry, the most recent books were carefully read. Articles relative to this subject published in various educational magazines were read and analyzed.

As it was impossible for the writer to make a complete study of all the high schools of the state of Massachusetts, he limited his study to three distinct types of high schools: Quincy High School, a large coeducational school; Haverhill High School, a smaller school in a different type of community; and the Dorchester High School for Boys.

Limitations

No attempt was made by the writer to consider all the plans of providing for individual differences. The writer has limited this study to individual differences in mental capacity of pupils taking high school chemistry, and the more widely used plans of individual instruction: namely, the Dalton Laboratory Plan, the Winnetka Plan, and the Morrison Plan.

Contributions of the Study

It is hoped that this study will make available information on the following points:

1. The range of differences among high school pupils taking chemistry.

2. The need for individual instruction.

3. The advantages and disadvantages of the three most widely used plans of individual instruction.

The Problem

Within the last two decades a great deal of literature has been published concerning individual differences. Everyone agrees that the range in ability of individuals to acquire information and skills is very wide. But due to the recent influx of pupils to school, whom Dr. Butterfield calls the "New Fifty Per-Cent", the writer feels that a study of individual differences will be interesting and worthwhile.

The problem selected for this paper is one which is a restricted study of differences in ability of pupils taking High School Chemistry, and the more well known methods of meeting these differences.

Need for Study

The term "individual differences" has found its place

in educational terminology, and that it should be recognized in our teaching procedure is accepted by practically everyone. But these questions remain open in a large percentage of our high schools: What are we going to do about it? How are we going to meet the needs which we know exist? How can the teacher with a heavy load solve the problem of individual differences?

That the needs are too important to continue a laissez-faire policy, all educators are beginning to realize. We know that upon able and intelligent people depends the progress of our civilization, and that the problems of society are greater if we do nothing for the failures of the schoolroom.

In modern progressive high schools there has been a tendency to reorganize chemistry into general chemistry, household chemistry, industrial chemistry, and college chemistry. This has been an attempt to meet the varying needs of the pupils. The training which each pupil needs most is that which will help him to be successful in life. Material which will be of use to one person may have no place in another's occupation, vocation, or life. But coupled with these varying needs are the differences in ability and achievement of each pupil. In a study made by Douglass, he found that the ablest pupil in an unselected class of thirty pupils was able to solve five times as many problems in a certain space of time as the poorest pu-

pil.[1] Therefore, each pupil presents a separate problem, and some method of instruction should be found whereby the needs of the various members of such a school may be met.

A group of teachers were asked to jot down on a slip of paper one or two of the most pressing problems they have had to face during the school year. More than half of the group referred to situations involving the needs of individual pupils rather than of the class as a whole -- individual needs resulting from individual differences.

Typical of the specific problems which were submitted are the following:

1. "How to keep 'quick' pupils interested while the 'dull' ones recite.

2. "Discipline of the super-normal and the subnormal child (and get teacher to realize their difficulties.)

3. "How to provide for individual differences in a two-grade room, with necessary short periods.

4. "Methods with dull children."[2]

It is thus apparent what the major problem is that confronts many teachers. It is quite obvious to many teachers that any attempt to treat the pupils as a class or a group will fall short of accomplishing the desired results.

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1. Douglass, A.A.,"Secondary Education,"p.195.

2. Borgeson, F.C., "The Individual Child", Educational Method, Volume VIII (June, 1929), p.505.

It is of paramount importance, then, that a way be found to meet the needs of the pupils taking chemistry, and to avoid the pitfalls of group instruction and the tragedy of pupil failure. The best way to solve this problem, in light of our present knowledge of psychology, is by some form of individual instruction.

A number of efforts have been made to formulate some scheme of individual instruction which would be adaptable to the present educational system. Some have failed; many have proved helpful; while others have been used successfully in some subjects and not in others.

It is obvious that these different plans of individual instruction have many advantages as well as disadvantages; yet it seems quite possible that a study of these various attempts at individual instruction may result in the accumulation of considerable information which will be of benefit to teachers of chemistry.

CHAPTER I

The Objective of Chemistry

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The Objectives of Chemistry

Chemistry is a branch of physical science which deals with matter in all its forms, its conditions, and its manifestations. Consciously or unconsciously every person is influenced and controlled by matter and chemical reactions. There is practically nothing around us with which chemistry does not deal in one phase or another. Be it paper, glass, ink, drugs, the body itself, the food that we eat, and the ground upon which we walk, chemistry plays an important part in all. There are many ways in which the knowledge of chemistry touches the life of every man, woman and child. Each man's life, as he lives it under the present conditions of our modern civilization, has been made possible only by the knowledge of chemistry which the world has come to possess. The great importance of chemistry to every human being and the large number of fields in which chemistry plays an important part, brings up the question of what should be the objectives of high school chemistry.

S. R. Powers of Teacher's College, Columbia University, determined the following objectives through the analysis of literature on chemistry, as well as prefaces of several textbooks:

1. "To give to pupils a broad genuine appreciation of what the development of chemistry means in modern social, industrial, and national life.

2. "To satisfy the natural interests in the things and

CHAPTER I

The Objective of Chemistry

forces of nature with which men are surrounded and with which they must deal; to give information which is interesting, purely for its own sake.

3. "To provide opportunity for the pupil to become acquainted with the applications of chemistry to industry for the purpose of educational and vocational guidance and possibly to furnish a beginning of vocational training.

4. "To develop such concepts and natural laws as the ultimate composition and indestructibility of matter, nature of chemical composition, interrelation of chemical elements, etc., to the end that science and reality may function in place of superstition and uncertainty in explaining natural phenomena.

5. "To contribute such specific ideals, habits, and concepts as those of accuracy, achievement, persistency, open-mindedness, honesty, cause and effect, which are essential to the study of science.

6. "To develop system, order, neatness, and possibly other attributes to the end that they will function in the ordinary affairs of life.

7. "To afford in some measure an opportunity to show the importance of scientific research and to stimulate the spirit of investigation and invention on the part of the pupil.

8. "To give to children full opportunity to indulge in the playful manipulation of chemical material in order that they may explore the world of reality as widely and as deeply as possible.

9. "To provide opportunity for acquaintance with such applications of chemistry in public utilities in order that the pupil may more adequately fulfill the duties of citizenship.

10. "To provide opportunity for acquaintance with such applications of chemistry as contribute to the maintenance of the health of the individual and the community.

11. "To provide opportunity for acquaintance with the elementary laws of nature which aid in understanding those citizenship problems which arise in connection with such topics as utilization of waste products, elimination of smoke, pure foods, etc.

12. "To make pupils able to read more intelligently and with greater interest, articles on chemistry in magazines and in

scientific books of a popular character.

13. "To give such training as will result in increasing respect for the work of recognized experts."[1]

The Committee on the Sciences of the Commission on the Reorganization of Secondary Education in 1920 was convinced that, irrespective of any deferred values, the materials of instruction should be intrinsically valuable, and the study of any division of the field should be distinctly worthwhile, regardless of any further science courses the student might elect. The committee set forth the following objectives:

1. "The development of interests, habits, and abilities of real significance in the life of man.

2. "The acquisition of direct, effective and satisfying methods of problem solving.

3. "The stimulation of more direct and purposeful social activities as a result of the appreciation of modern scientific technic improvements.

4. "The control of a large body of facts and principles of significance in the home, the school and community.

5. "An appreciation of services of science has rendered the human race together with an appreciation of the privileges, the duties, and the responsibilities incumbent upon those privileged to live in this age where science has received such wide recognition."[2]

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1. Curtis, F.D., "Second Digest of Investigations in the Teaching of Science", pp.268-269.

2. "Report of the Committee on the Reorganization of Science in Secondary Schools", U. S. Bureau of Education Bulletin, No. 26., 1920, pp.11-15.

These objectives or aims of chemistry can really be reduced to two: (1) that of giving an understanding of the significance and importance of chemistry in our national life; and (2) that of giving information of definite service to home and daily life. It is interesting to note that training for college chemistry does not appear in these objectives, although it may be implied. But even with the changing of objectives and the shifting of emphasis away from preparing for college, in many schools training for college chemistry still remains the main objective.[1] Dr. R. K. McAlpine, of the University of Michigan made a study of high school chemistry in Michigan, and he found out that only about 2.5 percent of the high school pupils in Michigan take a continuation chemistry course in the University. Assuming that twice as many take chemistry in other colleges, the figures would still show that only 7.5 percent continue work in chemistry. This is hardly sufficient to warrant setting up training for college chemistry as a major aim in the secondary school.[2]

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1. National Survey of Secondary Education Bulletin, 1932, No. 17 (Monograph No. 22), p.37.

2. McAlpine, Dr. R. K., "Some Aims in Teaching Chemistry", School Science and Mathematics, Vol.XXVIII, (Feb., 1928).

CHAPTER II

Evidence of Need for Plan of Individual Instruction

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Evidence of Need for a Plan of Individual Instruction in Chemistry.

Due to the heavy elimination of pupils each year throughout the public school system one might expect that the pupils who reach the senior year of high school would be more or less homogeneous as far as their mental capacity is concerned.

"Evidence is available to prove that we still have much elimination from secondary school grades. This is true even in such a highly popularized situation as that of California. Using the total enrollment in that state in Grade VII in 1926-27 as a base and assuming it to be 100 percent, the percentage of the total number that reached Grade XII, was 37.9. The exodus from the grades of which this data is symptomatic is much greater in many states and local communities."[1]

L. M. Terman in his book, "Intelligence of School Children", states that in the average American city not more than 40 percent of the pupils who enter the first grade remain to enter high school, and ordinarily not more than 10 percent graduate from high school.[2]

In the case of 318 cities studied by Strayer, the central tendency was for about 37 percent to enter the first year of high school, 25 percent the second year, 17 percent the third year, and 14 percent the fourth year. These figures go to show that it is not uncommon for one-third to drop out the first year and then a certain percentage each year, so that by the time the se-

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1. Koos and Kefauver, "Guidance in Secondary Schools", p.8.
2. Terman, L.M., "Intelligence of School Children", p.94.

CHAPTER II

Evidence of Need for a Plan of Individual Instruction in Geometry.

Due to the heavy elimination of pupils each year throughout the public school system one might suspect that the pupils who reach the senior year of high school would be more or less homogeneous as far as their mental capacity is concerned.

"Evidence is available to prove that we still have much elimination from secondary school grades. This is true even in such a highly populated district as that of California. Using the total enrollment in that state in Grades VII in 1928-29 as a base and assuming it to be 100 persons, the percentage of the total number that reached Grade XII, was 37.9. The exodus from the grades of which this data is symptomatic is much greater in many states and local communities."[1]

L. M. Terman in his book, "Intelligence of School Children", states that in the average American city not more than 60 percent of the pupils who enter the first grade remain to enter high school, and ordinarily not more than 10 percent graduate from high school.[2]

In the case of 815 cities studied by Strayer, the general tendency was for about 87 percent to enter the first year of high school, 75 percent the second year, 17 percent the third year, and 14 percent the fourth year. These figures go to show that it is not uncommon for one-third to drop out the first year and then a certain percentage each year, so that by the time the re-

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1. Rose and Strayer, "Guidance in Secondary Schools", p.6.
2. Terman, L.M., "Intelligence of School Children", p.24.

nior year is reached only about 35 percent of the pupils who started high school reach the XII grade.[1] Thus it would seem very probable that the pupils in the twelfth grade would be a rather highly selective group. Furthermore, chemistry has had the reputation of being a difficult subject for high school pupils, and it would be natural, therefore, that a large number of pupils would avoid a course in chemistry and take some other science, for a year of science is often required for graduation from high school. This would lead one to believe that the pupils taking chemistry in our high schools would be more or less homogeneous in regard to their mental capacity.

The purpose of this study was that of finding out if the pupils taking chemistry were more or less homogeneous in as far as their mental capacity was concerned, or whether wide differences could be found which in turn would require recognition in our teaching practices. This study includes a study of individual differences based upon group intelligence test of 757 pupils taking chemistry in the following high schools in Massachusetts: Quincy High School, Dorchester High School for Boys, and Haverhill High School.

The writer obtained the following data in regard to intelligence of high school students taking chemistry in the forenamed high schools of Massachusetts.

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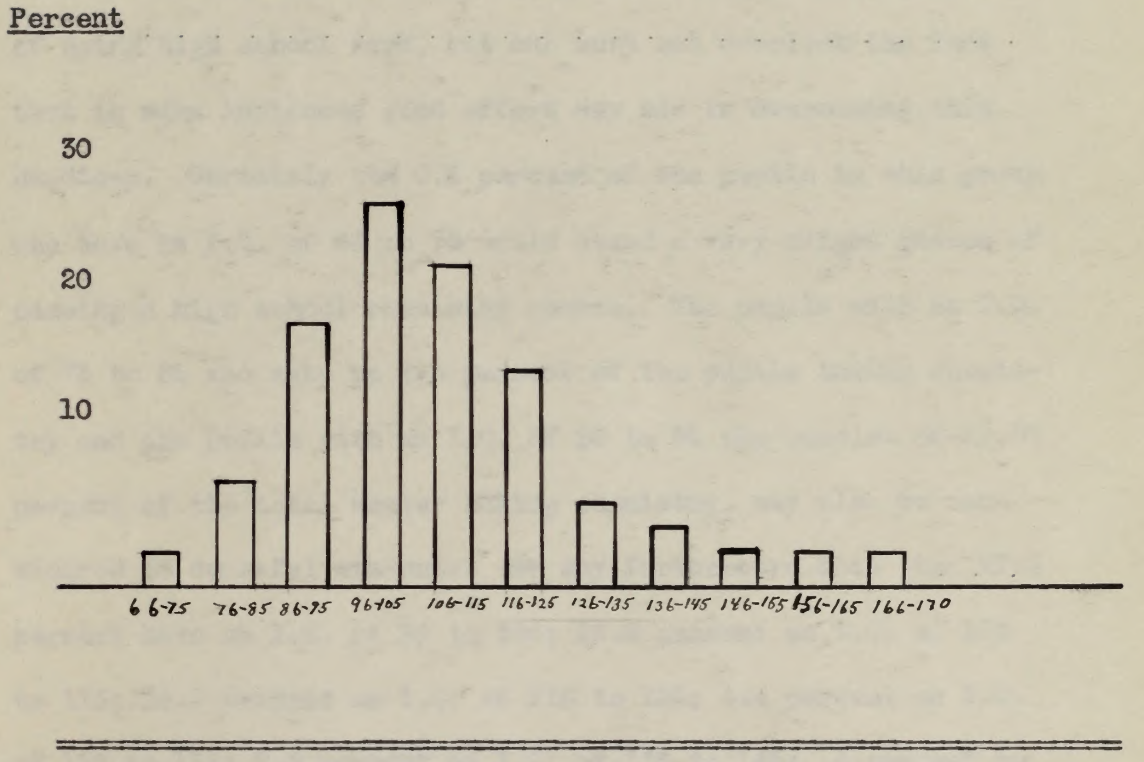
1. Strayer, G.D., "Age and Grade", Census of Schools and Colleges, Bulletin No. 451, U.S.Bureau of Education, p.6.

Table I

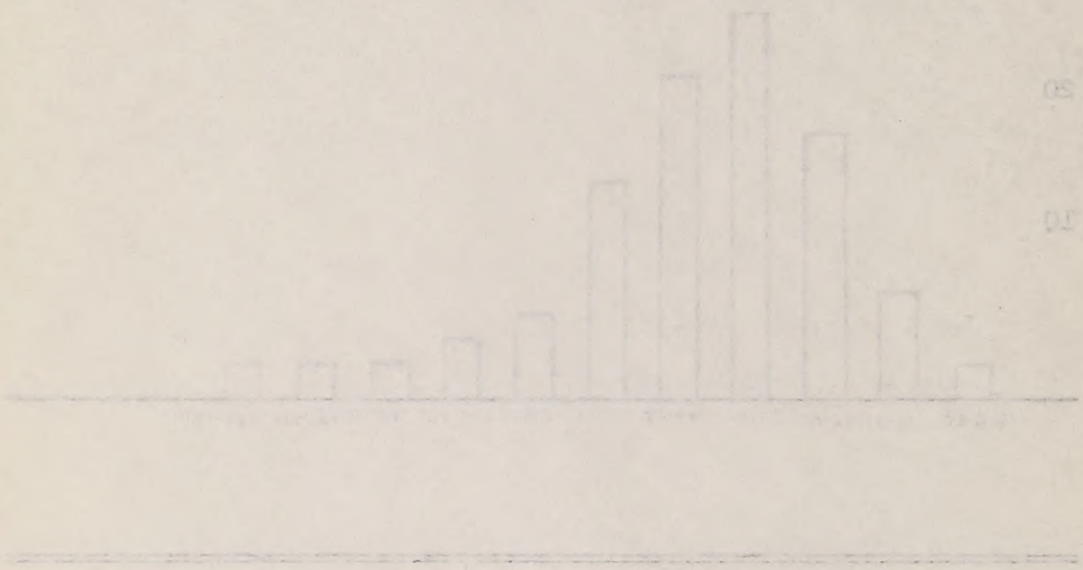
The Distribution of Intelligence

Showing Distribution of I.Q.'s of 757 Pupils
Taking Chemistry in Three High
Schools of Massachusetts.



This table gives perhaps, as true a description of the range of intelligence among pupils taking chemistry in the high school as can be given to date.

The table shows a number of astonishing facts. It is evident that the group of pupils taking chemistry are not as highly a selective group as one might expect, but it does, however, show some indications of selection in that 72.8 percent of the pupils taking



chemistry were above normal in intelligence. Terman considers pupils who have an I.Q. of 95 or over as normal and able to do high school work. Another fact that one may note is that 27.2 percent of these pupils taking chemistry were below normal. There is some question as to whether these pupils are capable of doing high school work, but one must not overlook the fact that in many instances good effort may aid in overcoming this handicap. Certainly the 0.6 percent of the pupils in this group who have an I.Q. of 66 to 75 would stand a very slight chance of passing a high school chemistry course. The pupils with an I.Q. of 76 to 85 who make up 7.5 percent of the pupils taking chemistry and the pupils with an I.Q. of 86 to 95 who consist of 19.07 percent of the total number taking chemistry, may also be considered as doubtful students. We may furthermore note that 27.2 percent have an I.Q. of 96 to 105; 22.5 percent an I.Q. of 106 to 115; 14.9 percent an I.Q. of 116 to 125; 4.4 percent an I.Q. of 126 to 135; 2.8 percent an I.Q. of 136 to 145; .4 percent an I.Q. of 146 to 155; 0.14 percent an I.Q. of 156 to 165; 0.14 percent an I.Q. of 166 to 175. The pupils having an I.Q. of 95 to 135 are capable of doing high school work in chemistry, other things being equal. But the pupils with an I.Q. of 136 to 175 are able to do more than the ordinary course of chemistry in the high school requires. These pupils should be given extra work and more advanced work so that they may work up to their capacity and progress

accordingly.

Table I shows a wide range of differences in the mental capacity of students taking chemistry in the three high schools studied by the writer. This is what one may expect to find in almost any school. The range of differences may differ slightly from what the writer found, but the significant fact is that range of differences is so great that one cannot overlook them. It clearly shows the need for individual instruction, for even if these pupils were grouped according to guidance adjustment or mental capacity a wide range of differences would still be noticeable. It would seem that if pupils of inferior ability are going to be retained in the high school, and the writer's investigation shows that 27.2 percent of the pupils taking chemistry were pupils of inferior ability, then the school will have to do one of two things: either, (1) lower the standards; or, (2) add additional chemistry courses which are easier, but even then the problem would not be fully solved until individual instruction is resorted to. It may be feasible to lower the standards. It may be that we have judged the high school too exclusively by the difficulty pupils encounter in meeting its standards of graduation. It is true that largely through the influence of the college the bars have been raised until graduation is beyond the intellectual endowment of a large proportion of the children. But a nation falls short of the true ideals of democ-

racy which refuses suitable training to a third of its children merely because their endowments do not enable them to complete a course of study which will satisfy the college entrance.

It might be interesting to present data here to show what the tendency is at the present time in dealing with the pupils taking chemistry who are rather inferior as far as their mental capacity is concerned.

Table II

Percentage of Chemistry Pupils in the Industrial Cooperative Course Possessing Each Grade of Intelligence.

Intelligence Grades:	66-75	76-85	86-95	96-105	106-115	116-125
Percent of Total Who Made Each Grade on the Tests:	4.8	28.6	30.9	19.1	9.5	7.2

Table III

Percentage of Chemistry Pupils in the General Chemistry Course Possessing Each Grade of Intelligence.

Intelligence Grades:	66-75	76-85	86-95	96-105	106-115	116-125	126-130
Percent of Total Who Made Each Grade on the Tests:	1.5	10.6	15.9	34.1	26.5	9.1	2.3

In comparing Tables II and III, one may draw the general conclusion that there is a tendency in the high school to place the pupils taking chemistry, who possess a low mental capacity, into the Industrial Cooperative Course. The data on Table II shows that 4.8 percent of the pupils taking Industrial Cooperative Chemistry have an I.Q. of 66-75, while from Table III it can be noted that only 1.5 of the pupils taking the general course in chemistry have an I.Q. of 65-75. Furthermore, 30.9 percent of the pupils in the Industrial Cooperative course have an I.Q. of 86-95, while 1.59 percent of the pupils in the general course have an I.Q. of 86-95; 19.1 percent of the pupils in the Industrial Cooperative course have an I.Q. of 96-105, as compared with 34.8 percent in the general chemistry course.

This data rather definitely points to the fact that there is

a tendency to take care of the less capable students taking chemistry by offering a course in Industrial Cooperative Chemistry.

Although a large percentage of the pupils in the Industrial Cooperative course have a low I.Q., there is a wide range in the intelligence quotients. These range from 65 to 125. Thus it is evident that individual differences cannot be taken care of merely by offering different courses in chemistry. Furthermore, the purpose of the Industrial Cooperative Chemistry course is not to supply a course for pupils of low mental capacity, but to meet the needs of the pupils who plan to enter some industry after they complete their secondary education.

The data on Table III shows that 82 percent of the pupils taking the general chemistry course possess an I.Q. of 96 or above, but the range in I.Q.'s is from 66 to 130. With such a wide range in intelligence, many difficulties arise in teaching this course which can perhaps be best solved by individual instruction.

The reason, perhaps, for such a wide range in intelligence may be that the schools from which this data was received required at least one year of science before graduation from high school. General chemistry is usually provided for the large majority of pupils who do not know what they expect to do in the future, and who have not received sufficient guidance in selecting

their work. The pupils planning to enter college and take up chemistry for their life work must be adequately prepared in high school so that they may continue their study without wasting time learning in college what they should have learned in high school.

Some high schools offer a course in "College Chemistry", given with the purpose of meeting the needs of pupils who are planning to enter college. Pupils going into training as nurses, dietitians, and as those who plan to assume household duties have different needs from those going to college; therefore, in many schools a course called "Household Chemistry" is given with the purpose of meeting the needs of these particular groups.

All these courses are offered with the purpose of meeting the various needs of the pupils; but coupled with these varying needs are differences in ability. They cannot be met by merely offering different courses in chemistry and maintaining the group method of instruction. Many educators state that the recitation method of instruction does not meet the needs of the pupil.

"The recitation method almost universally used in the public schools is generaly acknowledged to be inefficient because (1) it sets the same pace for all pupils in the class, a pace too slow for the more clever and too fast for the more stupid; (2) it wastes the time of those who know the lesson and teaches little to those who do not; (3) it does not give to the teacher an accurate knowledge of the progress made by the bashful or slow pupil and brings in undesirable personal elements."[1]

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1. Fletcher,G.S., "Use of Printed Practice Sheets and Standardized Test in Teaching School Subjects", School and Society, Vol.XXXII, (August 23, 1930), pp.264-65.

"It is essential also that the teacher should not be laden with slavish, recitation work. There must be opportunity; first, for intimate association with pupils in kindred pursuits; second, for the lighting of the pupil's touch at the altar of inspiration, by presentation of lofty personal ideal; third, for the communistic enjoyment of the discoveries of correlated labor. These essentials can obtain to only limited extent under the slavish exactions of hearing recitations, marking time, and keeping up to the mechanical assignments demanded by the graded system."[1]

"The class system involves many disadvantages. (a) It may lose sight entirely of individual differences becoming a 'machine' in the worst sense of the term. (b) It tends to impart instruction with reference to an ideal 'average child' who may have no existence in reality. (c) It may involve conditions that are injurious to health of the weaker pupils in the worry and overstrain that result from an attempt to keep 'up to grade'. (d) It undoubtedly tends to discourage a certain proportion of pupils and to keep them from continuing with the work of the school."[2]

"Is not the recitation a fearful bore to the visitor who is forced to sit through its long, tortuous, and uninteresting passage? If this is true in experience of visitors, who escape as soon as common courtesy permits, what then of the pupils who spend the greater part of their school lives in its unproductive passivity and are supposed to be interested and normally profited when they are not?"[3]

"It is sufficient here to note that a great deal of time is wasted in recitations. The writer has observed a recitation in which ten minutes were spent in clearing up a point that one pupil and only one had failed to grasp in the previous assignment. At least one hundred minutes in the aggregate were thus wasted. The only way in which to eliminate such waste is to provide some time for individual work."[4]

The group method of instruction encounters another difficul-

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1. Search, P.W., "An Ideal School", p.291.

2. Bagley, W.C., "Classroom Management", p.214.

3. Search, P.W., "An Ideal School", pp.293-94.

4. Bagley, W.C., "Classroom Management, p.213.

ty: a large number of pupils drop out from school at an early age, and in the majority of the cases the withdrawal is due to lack of interest. This failure of pupils to attend the school in large numbers may be traced to failure or inability of the school to provide for the vital needs of the individual pupil.

"It is the very system (the group method) however, that is so organized as to prove the very greatest of all causes for early withdrawal from school.... The tendency of all classification is to unite pupils of widely different attainments..... The consequence is that the lesson is too short for some and too long for others. The best pupils in the class are not tried to the extent of their ability.... The poorest pupils in the class are strained to their utmost. They are dragged, as it were, over the ground.... This develops the result that the overworked pupils are frequently discouraged and drop out of the school altogether."[1]

The quotations indicate why many educators urge the need for a change in our system of training youths. Recognizing these undesirable factors in our educational system, progressive educators have devised and resorted to various educational devices. Foremost among these is individual instruction in one form or another. Individual instruction and supervised study are two of the earliest attempts to remedy the difficulties which the psychology of individual differences revealed as inherent in the recitation.[2]

The pupil of low ability and the pupil of superior ability

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1. Parker, S.C., "Methods of Teaching in High Schools", p.366, quotation from W.L.Harris, Addresses and Proceedings of the National Educational Association, 1874, p.266.

2. Thayer, V.T., "The Passing of the Recitation, p.181.

have been neglected in our group scheme of education.

"Our schools are too prone to leave the discovery of important difference to chance. The low-ability pupil is too frequently discovered only through repeated failure. Instead of being led to master work of which he is capable, he is taught to fail."[1]

"The present neglect of superior talent is sufficiently indicated by inability of teachers to recognize it."[2]

The retarded or the duller pupils need individual instruction in order to accomplish better the tasks set before them, that the result will not be "half learning" but "mastery". For a habit or an item of knowledge which is not learned so that it can be used has little or no value.[3] Just as it is evident that the less bright pupil needs individual instruction, that he may utilize fully his limited capacity, so also is it desirable that the bright pupil receive individual instruction, that he may not waste his abilities.

Although individual instruction is highly recommended by a large number of educators, there is some question as to the desirability and actual practicability of individualizing instruction in all subjects. Some subjects, however, lend themselves quite naturally to this type of instruction; for example, spell-

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1. Mort, P.R., "The Individual Pupil", pp.22-3.

2. Ibid, p.23.

3. Monroe, W.S., "Directing Learning in the High School", p.72.

ing and mathematics.[1] Carleton Washburne, however, sees no reason why all subjects cannot be individualized.[2]

It is possible, then, that many subjects may be successfully individualized. This does not mean necessarily that all class work is to be abolished. Best results may be obtained by successfully combining both.

"It is clear that some form of compromise between individual instruction and class instruction is essential to the best work of the school"[3]

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1. Washburne, C., "Winnetka", School and Society, Vol.XXIX, (Jan.12, 1929), pp.39, 42.

2. Washburne, C., "A Program for Individualization", Twenty-fourth Yearbook, National Society for the Study of Education, pp.268-9.

3. Bagley, W.C., "Classroom Management, p.215.

CHAPTER III

A Study of Plans of Individual Instruction

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A Study of Plans of Individual Instruction.

The earliest method of education was highly individualized. Children received their education and training at home from their mothers or fathers. Later, when our first schools were established, some of the children began to receive their instruction in the schools. But even in the first schools the instruction was largely individual. Up to the nineteenth century the common method of instruction in the schools was individual instruction.[1] The pupil advanced to the teacher's desk when his turn came, recited upon the work which he had prepared, received a new assignment in form of directions, and returned to his seat to continue his studying.

When education became more popularized and the classes became larger, a form of instruction known as the group instruction was employed. While this form of instruction had many advantages, there was something lacking in it. As early as 1872 Mr. William T. Harris, then United States Commissioner of Education, called the attention of educators to the fact that class

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1. Parker, S.C., "Methods of Teaching in High Schools", p.363.

instruction was not in all respects advantageous.[1] Many educators began to search for the cause of the difficulties and ways of overcoming these obstacles. It was recognized that individual differences in children were neglected and that a method should be found whereby more attention could be paid to the individual and at the same time retain the advantages derived from group activity. Individual instruction conducted through groups appeared to be the probable solution of the perplexing problem.

In 1888, P.W.Search, superintendent of the schools of Pueblo, Colorado, introduced a plan of individual instruction into the high school. The plan was also tried in many other schools and the reports concerning the success of this scheme of instruction were favorable, and in some instances very favorable.[2]

A little over a decade later, Dr. Frederic Burk of the San Francisco State Teachers' College made a study of individual instruction and applied some of his principles to the classroom. C. W. Washburne, a former pupil of Dr. Burk, saw the need for a form of individualized instruction in the public schools of Winnetka, Illinois. Mr. Washburne, using some of Dr. Burk's ideas, introduced a system of individual instruction which has

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1. Parker, S.C., "Methods of Teaching in High Schools", p.365.
2. Ibid, p.380.

come to be known as the Winnetka Plan.

In 1920, Miss Helen Parkhurst put into practice her method of instruction in Dalton, Massachusetts. This plan of instruction became known as the Dalton Laboratory Plan.

The third plan of individual instruction, which I shall discuss, is that devised by Professor Henry Morrison of the University of Chicago. His plan is known as the "Morrison Unit Plan".

I have included these three plans of individual instruction in my study because they are better known and more widely used than the other methods of individual instruction.

THE DALTON LABORATORY PLAN

The Dalton Laboratory Plan, as stated before, was originated by Miss Helen Parkhurst. Mis Parkhurst was very interested in the problem of dealing with the needs of the individual. In 1914 she went to Italy where she studied the Montessori Method. From 1915 to 1918 she acted as Dr. Montessori's assistant in this country. During this period she did some experimenting in cooperation with Dr. Burk of San Francisco State Teachers' College.

In 1919 Miss Parkhurst began her work in this field, in the ungraded school for crippled children in New York City. The

success of the plan with the crippled children inspired Mrs. W. Murray Crane, a trustee of the school, to try out this plan in the high school of her home town, Dalton, Massachusetts. Miss Parkhurst was called upon to establish the new plan in the Dalton High School, Dalton, Massachusetts, wherefrom the Plan derived its name.

The Dalton Laboratory Plan is based on three fundamental principles, according to Miss Parkhurst, and the success of the plan depends largely upon the extent to which these principles are adhered to. The first principle underlying the plan is freedom.

"By 'freedom', I mean freedom to work without interruptions in order to develop concentration. As applied to an individual, it is understood to mean that he is freed from those habits or conditions which enslave his life or impede his complete development."[1]

"This ideal freedom is not a licence, still less discipline. It is, in fact, the very reverse of both. The child who does as he likes is not a free child. He is, on the contrary, apt to become the slave of bad habits, selfish and quite unfit for community life. Under these circumstances he needs some means of liberating his energy before he can grow into a a harmonious responsible being, able and willing to lend himself consciously to cooperation with his fellows for their common benefit. The Dalton Laboratory Plan provides that means by diverting his energy to the pursuit and organization of his own studies in his own way. It gives him that mental and moral liberty which we recognize as so necessary on the physical plane in order to insure his bodily well being. Anti social qualities and activities are, after all, merely misdirected energy."[2]

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1. Parkhurst, Helen, "The Dalton Laboratory Plan, 24th Yearbook, National Society for the Study of Education,VII,p.84.

2. Parkhurst, Helen, "Education on the Dalton Plan", p.18.

In order to realize the first and main principle of the Dalton Plan, the pupils are allowed to do about what they wish, and spend about as much time as they wish upon a subject, as long as they accomplish what must be done in each subject.

The following quotation expresses definitely the reason for this freedom:

"Unless a pupil is permitted to absorb knowledge at his own rate of speed he will never learn anything thoroughly."[1]

The pupil should be allowed to continue working upon any subject to which he is at the time directing his energies, for when he is highly interested and absorbed in his work his mind is keener, more alert and more capable of mastering any difficulties that may arise.

The second principle which is the plan's contribution to educational procedure is cooperation or the interaction of group life. If we hope to have a better democracy we must begin in the schools and train our children so that they may be intelligent participators in that form of society. A democratic institution demands cooperation and interaction of group life. Dr. Dewey in his book "Democracy and Education" expresses the idea underlying this principle rather concisely.

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1. Parkhurst, Helen, "Education on the Dalton Plan", p.18.

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1. Parkhurst, Helen. "Education on the Dalton Plan", p.18.

make an individual an intelligent participator in the life of his immediate group, but to bring the various groups into such constant interaction that no individual, no economic group, could presume to live independently of the other."[1]

In a school of this type the pupil functions as a member of a social group. He enjoys the opportunity of being a member of this social group, providing he makes the necessary adjustments. When working on an assignment he attempts to overcome the difficulties himself, but if he needs help he is free to consult his fellow pupils or the teacher. The teachers must cooperate with each other and with the pupils if success is to be achieved.

"For the real problem of Education is not a teacher's problem for the difficulties that harass the teachers are created by unsolved difficulties of the pupils."[2]

The Dalton Laboratory Plan allows the pupil to budget his time. This is the third principle underlying this plan. The pupil budgets his time and can thus give each subject a definite amount of time basing his judgment, as to how much time he needs, upon the difficulty of the subject. It is reasonable that the pupil should budget his own time for nobody knows better, than the pupil himself, what subjects are difficult to him and in what subjects he should spend the most time. He will learn to rely on his own judgment and will not have to depend upon the teacher. He will develop a sense of responsibility and acquire the ability

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1. Dewey, Dr. John, "Democracy and Education", Chapter VII

2. Parkhurst, Helen, "Education on the Dalton Plan", p.28.

to proportion effort to attainment.

Under the Dalton Laboratory Plan classes are not abolished, nor is it desirable that they be abolished. The instruction is individual instruction through groups. Each pupil is classified as a member of a form, and for each form a maximum and a minimum curriculum is drawn up. The work in any given subject for the school year is divided into jobs, comprising one month's work. The pupil receives an assignment of all his work for one month at a time in the form of a job which he accepts as a contract. The pupil chooses his own time, during certain hours of the day, for doing the various elements of his month's contract in rooms devoted to the various subjects. As some arbitrary period of time must be set for the completion of each job, so one month or twenty days is given. It is not required that all pupils finish in this length of time. If some pupils do not finish their job in the time set arbitrarily, they may work on it until they have completed it. On the other hand, if the pupil finishes all the work in all subjects before the end of the month, he receives additional work or goes on to the next contract. No pupil, however, may proceed to the next contract in any given subject until he has completed the assignments in all subjects. It is the essence of the Dalton Plan that pupils should progress each at his own rate, for only so can the work be assimilated thoroughly.[1]

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1. Parkhurst, Helen, "Education on the Dalton Plan", p.39.

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1. Parkhurst, Helen, "Education on the Dalton Plan", p.33.

Actually the Dalton Plan is not a complicated scheme of instruction and organization. Miss Parkhurst thinks that it can be applied to the organization of any school with the exception of primary schools designed for children under nine years of age.[1] The pupil when he comes to school in the morning chooses what he wishes to work at in the morning. He plans his attack and then commences to work. He does not have to leave the work after a period of forty-five minutes or so, for there are no class periods in the morning, thus he may spend the entire morning on one subject if he so desires. This is called the "Laboratory Time". Of course, a pupil of nine years and under has not the tool subjects sufficiently well at hand to enable him to work independently. The morning session closes with a conference time. The pupils meet each subject teacher once a week in a conference, during which time reports, reviews, and anything considered significant, are given. It is not considered as a time for presenting new material. Problems are discussed if there are any. Ideas are exchanged and difficulties cleared up. The conference period offers an opportunity for group interaction, although pupils are allowed to work in groups during the "Laboratory Time" and assist each other. This is a desirable feature of the Dalton Laboratory Plan.

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1. Parkhurst, Helen, "Education on the Dalton Plan", p.45.

"In any adequate program of individualization, the group must remain. Individuality must emerge in group life. Individual differences must be provided for. Individualization of instruction must mean the meeting of individual needs through the group (1) by adapting to individual differences and (2) by providing for maximum development of individuality."[1]

The afternoon session of the Dalton School is given over to scheduled periods for such activities as music, art, physical education, industrial and domestic arts, assemblies, chorus,and student government.

The traditional classrooms are transformed into subject matter laboratories instead of being arranged according to grade. The textbook library is distributed among these laboratories according to subject. Thus all material for history is assembled in one room. All the necessary equipment for science is assembled in another, and so on for each subject. Each laboratory has a laboratory specialist in that particular subject, and thus pupils of all grades may be working on various problems in the same laboratory. The Daltonians recognize that assignments are the heart of the plan.[2] Thus great care must be taken in making out the assignments. They must be clear and worthwhile, not too difficult nor too easy. They must be given or stated in a vocabulary which the pupil can understand. The contracts are usually

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1. Pierce, Mary D., "Individual Instruction", National Educational Association Proceedings, 1929, p.494.

2. Lynch, A.J., "Individual Work and the Dalton Plan", p.47.

printed or mimeographed and given to the pupils. They may contain full directions or a guide sheet may accompany the contracts. Miss Parkhurst considers the assignment an important factor in successful teaching. She gives two complete chapters of discussion on the assignment in her book, "Education on the Dalton Plan".[1]

"The first condition of a good assignment is that it shall be invariably written, not oral, clearly expressed, and designed to show the pupil what it is leading up to. In drawing it up the teacher must get rid of the idea that she is preparing a plan for herself. What is needed is a plan to be used by the pupils as a guide in their attack upon the parts of their contract-job. A good assignment represents a block of the whole job compiled from the standpoint of the pupil himself."[2]

The various teachers make out the assignments for their courses. The teachers having the same pupils hold conferences during which all the assignments are revised with a view of correlation and integration. A great deal of repetition is avoided by this method, and it undoubtedly results in better assignments than would be developed ordinarily by the individual teacher working independently.

"One of the most distinctive features of the Dalton School is the integration of the pupil's work in the various subject-matter fields."[3]

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1. Parkhurst, Helen, "Education on the Dalton Plan", Chapters V and VI.

2. Ibid, p.58.

3. National Survey of Secondary Education Bulletin, 1932. No. 17, Monograph No. 13, p.282.

Another distinctive feature of the Dalton Laboratory Plan is the method of recording the progress of the pupil. Periodical tests and examinations are given in the Dalton school at the end of each month. But the place of tests and examinations in the Dalton Laboratory Plan is somewhat open to question. Miss Parkhurst has doubts as to whether examinations supply any real tests of the pupil's knowledge or ability.[1] However, the record of the pupil's progress is kept on a graph which has space where the results of examinations may be recorded. There are three kinds of graphs used to indicate the pupil's progress.[2] The instructor has one which is called the "Laboratory Graph", on which the pupil's progress is recorded by drawing a straight line to the right of the pupil's name, each cross-section space indicating one unit of work which has been completed. This graph is posted on the wall in the laboratory and each pupil records his own progress before leaving the laboratory. The instructor can then tell with one glance how the pupils are progressing and which ones need individual help.

The second graph is the pupil's "Contract Graph". On this graph the pupil keeps the record of his progress in all subjects. Thus the pupil can tell by a glance at the chart in what subjects

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1. Parkhurst, Helen, "Education on the Dalton Plan", p.140.

2. Ibid, pp.139,143,147.

he must spend more time or in what subjects he has progressed very rapidly.

There is usually a third graph which is called the "House Graph", upon which the progress of all the pupils in all subjects are recorded. Here the pupils can see where they stand in relation to other pupils in the school.

Roy O. Billett in his survey of schools using the Dalton Plan in the United States received the data given in Table IV:

Table IV[1]

Schools using the Dalton Plan or a modified Dalton Plan, classified according to type of organization.

Type of Organization	Number of Schools Reporting.	Dalton Plan				Modified Dalton Plan			
		Use		Use with Estimated Unusual Success		Use		Use with Estimated Unusual Success	
		Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
1	2	3	4	5	6	7	8	9	10
9 to 12	4,304	65	1	5	0	198	5	25	1
7 to 12	1,284	34	2	3	0	102	8	10	1
8 to 11	638	9	1	1	0	23	4	5	1
7 to 9	614	20	3	1	0	48	8	1	0
10 to 12	308	5	1	1	0	28	9	3	1
6 to 11	105	4	4	1	1	5	5	1	1
all others	1,341	25	2	3	0	82	6	7	1
Total	8,594	162	2	15	0	486	6	52	1

1. National Survey of Secondary Education Bulletin, 1932, No. 17 (Monograph No. 13), p.267.

From Table IV it will be noticed that the Dalton Laboratory Plan is applicable in any type of organization. Furthermore it will be noticed on Table IV that out of 8,594 schools replying, only 162 schools were using the so-called Dalton Laboratory Plan and 486 schools were using a modified Dalton Plan. Miss Parkhurst did not intend that her plan be used in every school in the form that she presented it in 1920. The following quotation from Miss Parkhurst's book, "Education on the Dalton Plan", will make this point clear.

"I have carefully guarded against the temptation to make my plan a stereotyped cast-iron thing ready to fit any school anywhere. So long as the principle that animates it is preserved, it can be modified in practice in accordance with the circumstances of the school and the judgment of the staff".[1]

Out of the 162 schools using the Dalton Plan, 15 schools reported using this plan with estimated unusual success. The number of schools using the modified Dalton Plan was 486. From this number, 52 schools reported they used this plan with estimated unusual success.

One may draw conclusions from this data that the tendency exists to use a modified Dalton Plan and that a surprisingly small number of the schools reporting have any considerable measure of confidence in the success of the plans. The plan is of recent origin in most schools that reported, and thus it is hard to esti-

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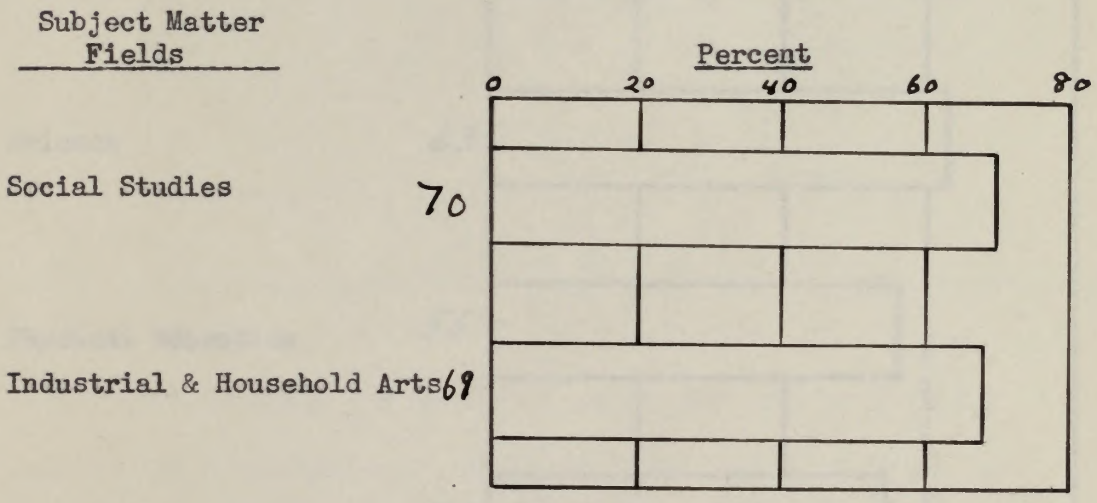
1. Parkhurst, Helen, "Education on the Dalton Plan", p.27.

mate the success of the plan. Eleven schools reported to have used this plan for five years, while sixteen reported to have had this plan in operation for less than two years at the time this survey was conducted by Billett.[1]

Various subjects may be individualized and presented by means of the Dalton Laboratory Plan.

Table V[2]



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1. National Survey of Secondary Education Bulletin, 1932, No. 17, Monograph, No. 13, p.277.

2. Ibid, p.278.

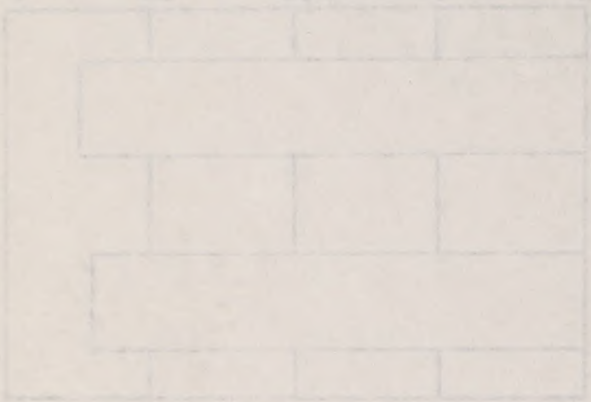

Table V (Continued)

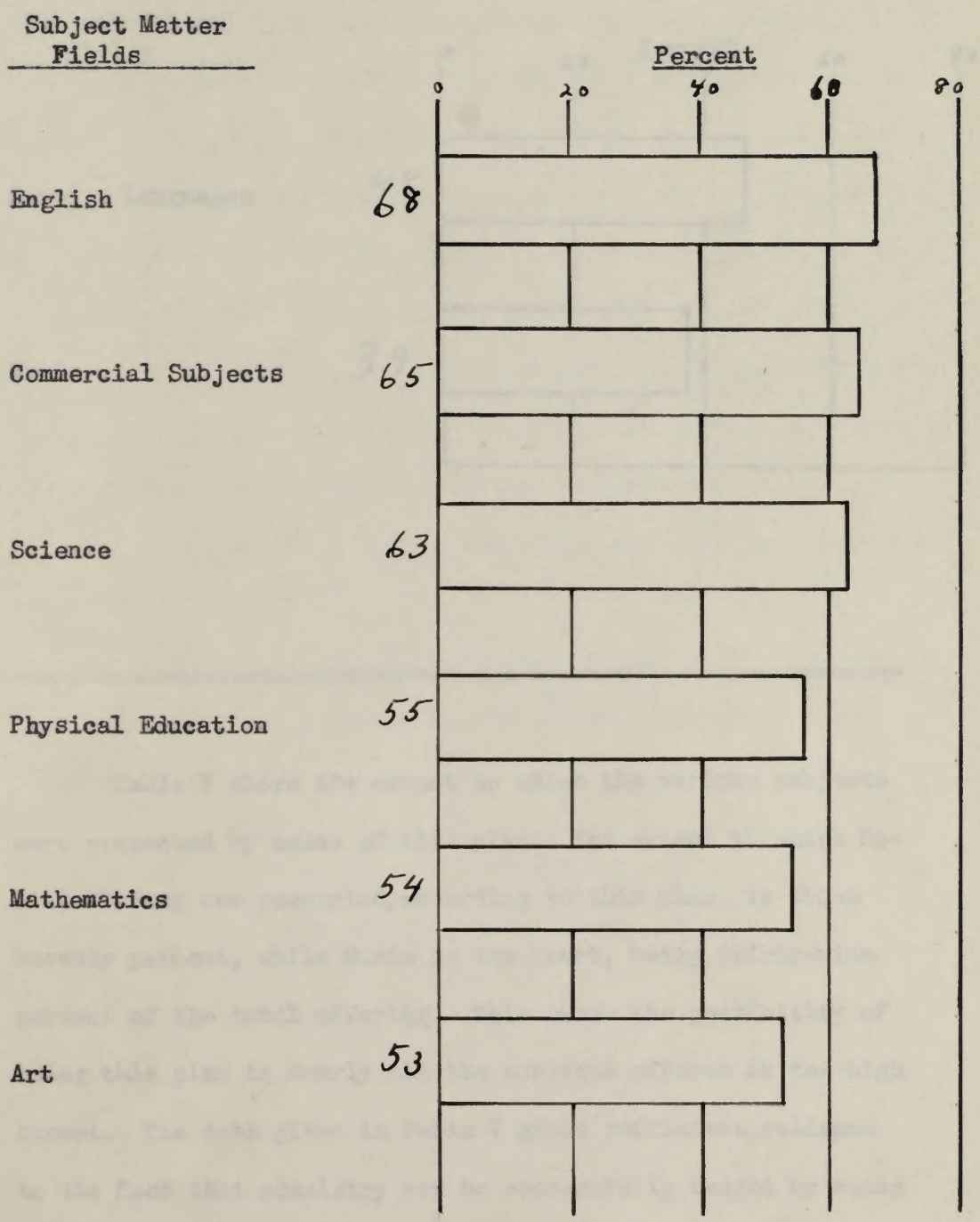

Table V (Continued)

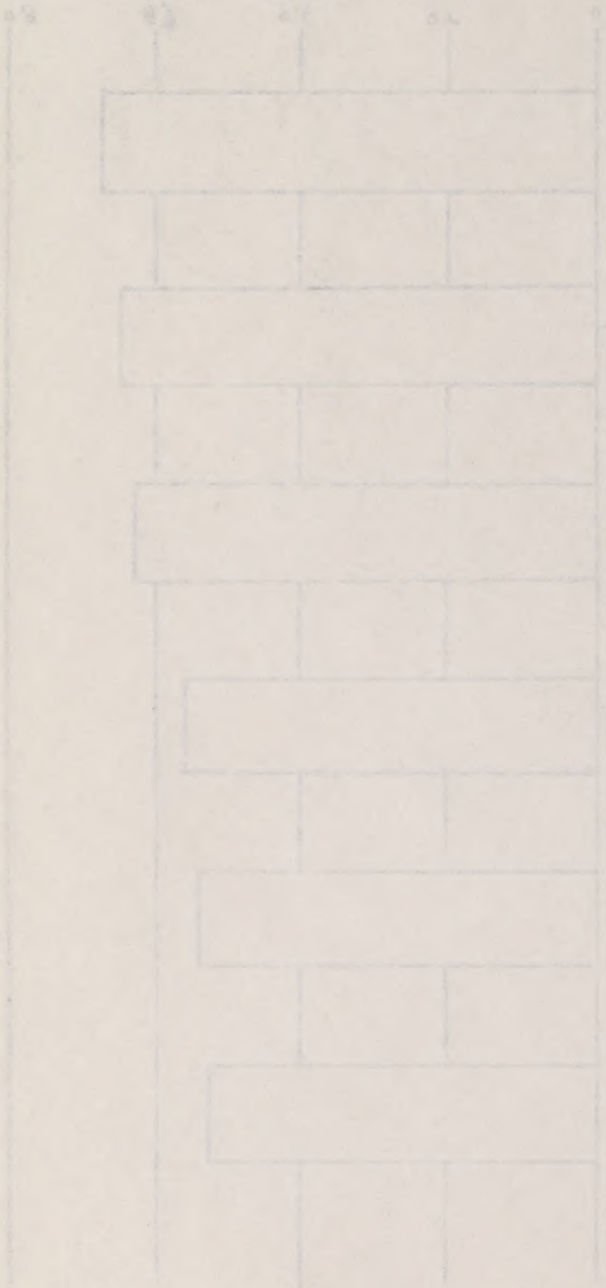

Table V (Continued)

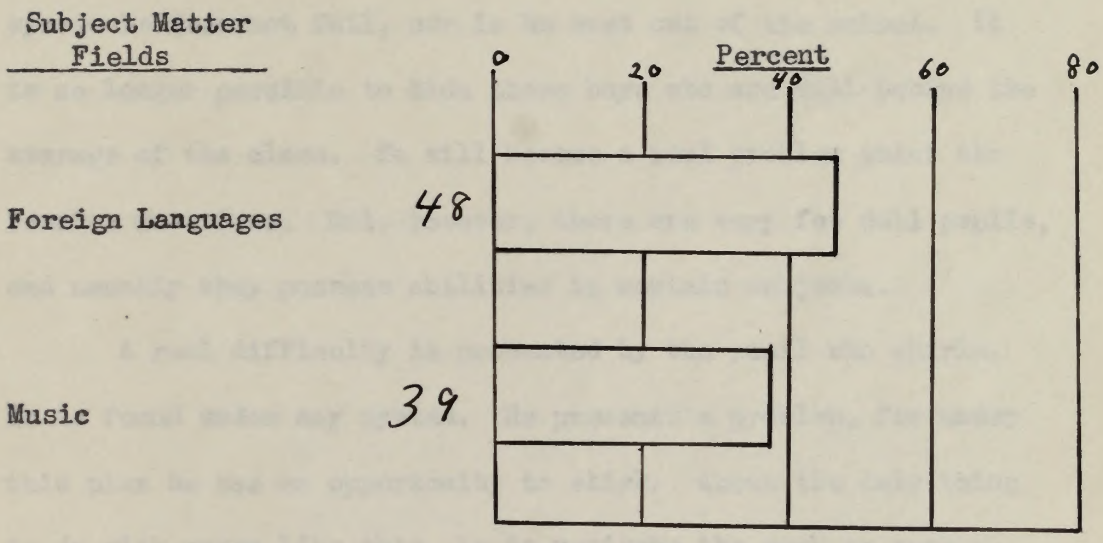

Table V shows the extent to which the various subjects were presented by means of this plan. The extent to which Social Studies are presented, according to this plan, is about seventy percent, while Music is the least, being thirty-nine percent of the total offering. This shows the possibility of using this plan in nearly all the subjects offered in the high school. The data given in Table V gives sufficient evidence to the fact that chemistry may be successfully taught by means of the Dalton Plan.

There are some difficulties of individual work. The first and most obvious is the so-called dull child. Under this system he does not fail, nor is he cast out of the school. It is no longer possible to hide these boys who are dull behind the average of the class. He will become a real problem which the teacher must face. But, however, there are very few dull pupils, and usually they possess abilities in certain subjects.

A real difficulty is presented by the pupil who shirks. He is found under any system. He presents a problem, for under this plan he has an opportunity to shirk. About the only thing to do with cases like this, is to motivate the work to such a degree that the pupil will get interested and then provide proper incentives.

Another difficulty that must be watched is the "racing" through assignments. This should be stopped and steady progress should replace any "racing".

> "The fact that a child does more work under this plan than the old system is one of the discoveries of individual work, but any suggestion that the principle should be adopted to 'squeeze' more work out of the boy should be strenuously fought."[1]

A difficulty associated more particularly with the inception of this plan is the setting down to work on the part of the pupils. The child needs guidance and supervision until he

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1. Lynch, A.J., "Individual Work and The Dalton Plan", p.91.

is oriented to this new plan. "Experience shows that it takes six months to accomplish that result."[1] It takes a long time for some pupils to adjust themselves to a new thing, therefore the teacher should not become discouraged if adjustments are not made in a short time.

Since no educational system is perfect, it is evident that some criticism is forthcoming. Kilpatrick offers the following criticism of this plan:

"The school is to be judged by the service it renders, to child and to society, and any scheme of education which does not result in the young growing properly up into adult life is justly to be condemned. But neither of these considerations, nor both put together, justifies us in reducing the education of childhood to learning what the adult will need. The gap between childhood and adulthood is too great. To disregard this, to reduce education to mere preparation, is the fatal defect in the Dalton Plan and the common notion.....

"The essential error of the Dalton Plan then is as with all external examination schemes, that it accepts childhood as a time of storing up learning to be used when called for at a remote day, frequently in adult life."[2]

Carleton Washburne and Myron M. Stearns offer the following criticism:

"One of the most serious arguments advanced against the plan is its encouragement of bad habits in the matter of procrastination. An assignment of work for a whole month is liable to mean time wasted at the beginning of the month and a lot of work crowded in at the end of the month."[3]

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1. Lynch, A.J., "Individual Work and The Dalton Plan", p.95.

2. Kilpatrick, W.H., "An Effort at Appraisal", 24th Yearbook, National Society for the Study of Education,Part II,pp.277-279.

3. Washburne and Stearns, "Better Schools", p.298.

Miss Lucy Wilson, former principal of the South Philadelphia High School for Girls, where the Dalton Plan has been in use, states that there is no special disadvantage to the pupil under this system of teaching. In her book, "Education for Responsibility" she gives the following advantages under this plan:

Advantages to the Child[1]

1. "Individual assignment removes most of the handicaps due to (a) a short memory span; helpful suggestions are at hand when needed.
(b) Absence: Assignments are sent home to the pupils when ill, but not in quarantine. Pupils may begin their work where they left off when they come back.

2. "Almost automatically, it takes care of difficulties due to different abilities, or different rates of speed, or both.

3. "It makes it possible not only to make the aim clear, but also to make it reasonably certain that each child sees each unit of work in its proper setting and perspective."

Advantages to the Teacher[2]

1. "It compels better and ever better pedagogy; the teacher must see her subject from the viewpoint of the child.

2. "It makes supervision efficient. A department head may know with a minimum of visiting, exactly how the work is being done, whether it is functioning and why. He is in a position to give first aid and professional advice; the teachers are in a definite position of being able to ask for help, concretely and definitely.

3. "It helps to discover children's difficulties and to

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1. Wilson, Lucy, "Educating for Responsibility", pp.10,11.

2. Ibid.

show that these may come from different causes, some of them curable.

4. "By posting the assignments in all subjects, according to grade, teachers get a bird's eye view of all the work, and are able to cooperate as never before.

5. "The substitute teacher is less of a problem and creates far less havoc.

6. "Teachers no longer shrink from being observed at work."

Miss Wilson states that except for more work at first required in making out individual assignments, there is no disadvantage to the teacher under this plan.

Additional advantages given by other writers:

1. This method permits continuity of interest and effort by minimizing artificial interruptions.[1]

2. It also permits children to learn by scientific methods to investigate and discover for themselves.[2]

3. Opportunity is equal for all.[3]

4. Failures and "lock-step" are avoided.[4]

5. Better training in responsibility, leadership, and initiative is provided.[5]

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1. Dewy, Evelyn, "Dalton Laboratory Plan", Chap. I

2. Ibid.

3. Daggett, C.J., and Peterson, F.A., "A Survey of Popular Plans for Instruction", Educational Administration and Supervision, Vol.XVIII, (October, 1932), p.509.

4. Ibid.

5. Ibid.

6. There is closer contact between teacher and pupil.[1]

7. The absentee problem is very well cared for.[2]

8. More assistance in study.[3]

One of the strongest points in favor of the Dalton Laboratory Plan is the fact that the plan seems to find favor in the communities in which it is used. Roy O. Billett in his survey of this plan found that it was accepted with great favor by pupils, community, faculty, and administration. In no instances were the pupils regarded as unfavorable toward this plan.

The chief characteristics of the Dalton Plan may be summed up as follows:

1. "It hinges upon the organization of assignments."[4]

2. Division of the curriculum into contract jobs requiring the acquiring of a fixed amount of work in a given time.[5]

3. Some provision is made for individual differences.[6]

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1. Daggett, C.J., and Peterson, F.A., "A Survey of Popular Plans for Instruction", Educational Administration and Supervision, Vol.XVIII, (October, 1932), p.509.

2. Ibid.

3. Ibid.

4. Thayer, V.T., "The Passing of the Recitation", p.204.

5. Daggett, C.J., and Peterson, F.A., "A Survey of Popular Plans for Instruction", Educational Administration and Supervision, (October, 1932), p.499.

6. Ibid.

4. Old time table is replaced by laboratory time provision.[1]

THE WINNETKA PLAN

Superintendent Carleton W. Washburne of Winnetka Schools, Winnetka, Illinois, received his training under Dr. Frederick L. Burk of the San Francisco State Teachers' College. When Mr. Washburne became superintendent of the Winnetka schools, he took over Burk's methods and materials and worked out a plan of individual instruction that could be applied in the public schools of Winnetka, from whence the plan derives its name.

According to the guiding philosophy of the Winnetka system, the test of a school is fourfold:

1. "There is a body of common facts and skills which all should acquire certainly and economically in preparation for adult life in modern society. A technique of self-directed study and progression through mastery has been developed for this need.

2. "Abundant, happy living in the now of childhood is an end itself as well as preparation for future life.

3. "Imagination, originality, and creativeness resulting in uniqueness of personality, are essential to happiness, through self-expression, and to social enrichment and progress.

4. "The emotions, habits, and skills of social membership and inter-dependence must be intensified in school life and expanded by actual and imaginative participation into a vital pro-

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1. Thayer, V.T., "The Passing of the Recitation", p.204.

gram of social self-indentification and suborination into adequate character."[1]

It is upon these four hypostases that the Winnetka curciculum is based.

"The curriculum is divided into two parts. One part deals with knowledges and skills of which everyone alike needs mastery. The other part provides for each child self expression and opportunity to contribute to the group something of his own special interests and abilities."[2]

One-half of each session is devoted to the acquisition of certain knowledges and skills and the other half of each session is occupied by appreciative, creative, and social enterprises, the doing of which is its own reward. It is here the Winnetka Plan differs from the Dalton Plan. Under the Winnetka Plan we have definite periods of time assigned to each subject, while under the Dalton Plan there are no definite periods assigned to each subject. The children move from room to room, according to a program, when the bells ring. This is not found in the Dalton school. The freedom allowed for study under the Dalton Plan is not given to those enrolled in the Winnetka Schools, with the exception of some self-reliant pupils. They may apply for the freedom and if the teachers approve of such action, the pupils are

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1. Logan, S.R., "The Winnetka Schools", National Education Association Journal (Feb. 18, 1929), pp.173, 174.

2. Washburne, C.W., "Burk's Individual System as Developed at Winnetka", 24th Yearbook, National Society for the Study of Education, Part II, p.79.

allowed to budget their own time as is the case under the Dalton Plan. These self-reliant pupils are few in number and many pupils prefer to follow the standard daily program, simply because it is convenient and well balanced. In general, however, definite time limits are set for each subject.

The Winnetka scheme for learning by set goals is, by comparison, a refinement upon the Dalton Plan.[1] It differs in that there are no time limits set for accomplishment of any lesson or subject. Instead of contracts as found in the Dalton Schools, the pupils in the Winnetka Schools work for certain goals. The pupils work with a desire to reach certain goals.

"The chief incentives depended upon are the intrinsic interest of the job, pride of workmanship, ambition to reach a higher level of achievement in the social and creative activities, the thrill of creative participation, and in general, the pleasure of meeting the approval of one's fellows."[2]

The Winnetka Plan calls for a reorganization of the subject matter. Textbooks of the traditional type are not adequate for use in the Winnetka School. They are used to supplement the textbooks prepared by the teacher, or "practice materials", as they are called. These books contain

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1. Kilpatrick, "An Effort at Appraisal", 24th Yearbook National Society for the Study of Education,Part II,p.280.

2. Logan, S.R., "The Winnetka School", Journal of National Education Association, Vol.VI, (June,1929), p.175.

definite instructions as to how to attack the work to accomplish the goals and they also contain a number of illustrations. The goal books contain a definite outline of the exact units of work to be accomplished and goals to be reached. A space is provided opposite each of these goals in which the teacher places an O.K. when it has been reached.

The pupil does the learning exercises and when he has completed a goal he goes to the teacher's desk to get an examination and goes to his desk and takes it. If he receives a 100% he starts on the next goal. If he fails to show mastery, he practices again, guided by the results of the tests, which show his weak points and takes another form of the same test when he thinks he has mastered the work.

There are no recitations for the purpose of showing the teacher what one knows, or does not know. The tests and personal supervision take care of this need much more thoroughly and economically. There is, on the other hand, much discussion in contemplation of action, although the goal books usually make things rather clear.

Washburne, as can be seen from the following quotation, feels that the goal books are very essential in using this plan of instruction:

"The goal books form a large step toward individual instruction. The pupil has the advantage of knowing what he is working for and noting clearly his own progress. Each goal becomes an individual project. Laziness is discouraged, so is

slipshod work."[1]

The following quotations briefly outline the technique of this plan:

1. "The objectives or goals are very specifically stated. They are determined, as far as possible, on the basis of research as to social needs and individual needs. They are attainable by every normal Child -- each Child must obtain one hundred percent mastery of each goal. Subnormal Children have a modified curriculum.....

2. "Materials of instruction have been prepared that are self-instructive and self-corrective.....

3. "Complete diagnostic tests have been provided in a number of forms....."[2]

The Winnetka Plan differs from the Dalton procedure in another respect. The degree of advancement a pupil makes in one subject is not conditioned upon his advance in other subjects as is the case under the Dalton Plan. It is usually considered advisable to have the pupils keep the work in various subjects on a fairly even basis, but it is not a requirement and the pupils may go on, if they desire, and have completed the preceding goal in that subject. One disadvantage of this procedure, as compared with the Dalton procedure, is that it prevents a planned correlation either among the various phases of the common essentials and the group, socialized, self-expressive, or

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1. Washburne, "Goal Books in Winnetka Schools", American School Board Journal, Vol.LXIII (December, 1921), p.32.

2. Washburne, C.W., "Winnetka", School and Society, Vol. XXIX, (January 12, 1929), p.48.

creative activities.

The promotion is continuous, although most of the changes are made yearly. Such placement is determined by social and physical characteristics and to a less extent by subject achievement, and is supposed to provide the association most conducive to the given child's development. Grade divisions in subject matter are still recognized, but they are more for administrative purposes than anything else.

In the appreciative group and creative activities,which total half of the school day, there are no questions in regard to promotion. The pupil contributes in these whatever he desires. There is no failure in this school, and neither does anyone repeat a course. The pupil's success is assured in all subjects, but his rate is commensurate with his own efforts and aptitudes.

As has been stated before, one-half of the total time in school is given over to socialized, self-expressive, or creative activities. The following quotation expresses clearly the reason for giving so much time for creative work:

"It is upon creative work, or more generally speaking, upon cultivating each individual child's variation from the standard or average, that progress depends."[1]

There is, however, a danger of centering the whole atten-

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1. Washburn and Sterns, "Better Schools", p.281.

tion and interest of schools on giving individuals an opportunity to differ from one another. The danger of producing a too highly individualistic type of society and destroying the cohesiveness of human society must not be overlooked. It is, therefore, necessary that much of the creative work be done in connection with some group enterprise.

"Children's social consciousness must be developed along with their originality. Any complete form of education must develop a deep and abiding sense of interdependence of the individuals who make up society as well as stimulate each of those individuals to the fullest possible growth of self-expression."[1]

These group and creative activities are frequently centered around the children's work in a particular subject. They may, however, include appreciation of art, music, and literature, the editing of newspaper and a wide variety of other things.

The purpose of creative activities is in one respect directly opposite to that of individual instruction. The pupil must consider other pupils as members of a social group. The objectives of socialized activities may be summarized as follows:

1. "To develop social consciousness,
2. "To stimulate variation, originality and initiative,
3. "To contribute ability or interest to the wel-

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1. Washburne and Sterns, "Better Schools", p.282.

fare of group enterprise."[1]

While this plan of instruction has been applied at Winnetka in the elementary and Junior-High-School, Washburne sees no reason why it could not be applied to High School.[2] He gives the following suggestions for inaugurating individual work:

1. "Determine the objectives.
2. "Use complete diagnostic tests.
3. "Know exactly what to teach.
4. "Supplement the test used with material prepared for individual instruction."[3]

Roy O. Billett in his Nation Survey of Secondary Education found that this plan of instruction was used in various types of organizations of the secondary school.[4]

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1. Washburne, C.W., "Winnetka", School and Society, Vol. XXIX, (Jan. 12, 1929), p.49.

2. Washburne, C.W., "A Program for Individualization", 24th Yearbook, National Society for the Study of Education, Part II, pp.268,269.

3. Ibid, p.269.

4. National Survey of Secondary Education, Bulletin, 1932, No. 17, Monograph No. 13, p.300.

Table VI[1]

Schools using the Winnetka technique, classified according to type of organization.

Type of Organization	Number of Schools Reporting	Schools Using the Plan		Schools using the Plan with estimated unusual success.	
		Number	Percent	Number	Percent
1	2	3	4	5	6
9 to 12	4,304	46	1	5	0
7 to 12	1,284	26	2	3	0
8 to 11	638	3	0	1	0
7 to 9	614	18	3	1	0
10 to 12	308	5	2	0	0
6 to 11	105	0	0	0	0
All Others[2]	1,341	21	1	4	0
Total	8,594	119	7	14	0

1. National Survey of Secondary Education, Bulletin, 1932, No. 17, Monograph No. 13, p.300

2. Schools with a typical grade combination.

Table VII[1]

Schools using the Pin-this technique, classified according to type of organization.

Type of Organization	Number Reporting	Schools Using the Plan	Schools using the Plan with modified success.
	Number	Percent	Number Percent
	1	2 3 4	5 6
9 to 12	4,304	44 1	3 0
7 to 12	1,984	58 3	3 0
8 to 11	578	3 0	1 0
7 to 9	814	18 5	1 0
10 to 12	304	8 3	0 0
8 to 11	104	0 0	0 0
All Others[2]	1,341	21 1	4 0
Total	8,829	110 7	12 0

1. National Survey of Secondary Education, Bulletin, 1932, No. 17, Monograph No. 11, p. 100

2. Schools with a typical grade combination.

From Table VI the following conclusions may be drawn: first, there are very few schools using this plan of instruction, for out of 8,594 schools reporting only 119 schools reported they were using this plan. Second, the schools using this plan of instruction have no great faith in the success of this plan, for out of 119 schools reporting the use of this plan, only 14 schools reported using the plan with estimated unusual success.

Table VII[1]

Percentages of total offerings in the academic and commercial subject-matter fields, presented by the Winnetka technique.

Subject-Matter Fields	Percent
Mathematics	49
English	31
Science	29
Commercial	26
Foreign Language	25
Social Studies	20

Table VII gives the proportion of offerings, of each subject-matter fields, presented by means of the Winnetka

1. National Survey of Secondary Education Bulletin, 1932, No. 17, Monograph No. 13, p.304.

technique. The non-academic subjects were omitted, which are usually highly individualized. There were only eleven schools reporting.[1] The academic and commercial subject-matter fields are represented. The percentage of the total represented shows that the range is from one-fifth in social studies to nearly a half in mathematics. The proportion of offering in the science field was 29 percent. This is sufficient to warrant the use of the Winnetka Plan in teaching chemistry.

Although very few schools are represented, and the study can thus not be very valid, it is interesting, however, to note the extent of the use of this technique.

There are many questions that can be raised in regard to individual instruction. The questions as to cost of individual instruction versus group instruction is often put forth. R.F.Judd of the University of Chicago undertook the research, for his Master's thesis, of finding out which instruction cost the most. He came to the conclusion that individual instruction cost no more than group instruction.[2]

Another question that is often asked and that is of

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1. National Survey of Secondary Education Bulletin, 1932, No.17. Monograph No. 13, p.304.

2. Washburne, C.W., "Does Individual Instruction Cost More than Class Instruction?", 24th Yearbook, National Society for the Study of Education,Part II, pp.201-205.

great interest to teachers is: Does individual instruction place a heavy burden on the teacher? A study conducted by C.W.Washburne reveals that individual instruction does not impose an undue burden on the teachers, although a great deal of work is required when it is first introduced.[1]

A third question often propounded is: Does individual work decrease retardation? One of the greatest single reasons for individual progress in schools is the large number of repeaters who clog schools everywhere, and go out into life with a sense of failure. Data from Winnetka schools appears to show that individual work and progress not only eliminates "failures" and repeaters, but greatly mitigates over-ageness. The percentage of over-aged children in Winnetka is only 14.4, as against 22.2 of other schools of similar social position and as against 35 to 40 for many industrial centers.[2]

The Winnetka Plan with all its improvements over the traditional school procedure, cannot pass without being challenged. Kilpatrick feels that the division of time into two distinct parts, one for acquiring knowledges and skills, and

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1. Washburne, C.W., "Does Individual Instruction Place Too Heavy a Burden on the Teacher?", 24th Yearbook, National Society for the Study of Education, Part II, pp.206,207.

2. Washburne, C.W., "Does Individual Work Decrease Retardation?", 24th Yearbook, National Society for the Study of Education, Part II, pp.185,186.

the other for the promotion of creative activities is its greatest fault.

"It tends to break the child's learning into two distinct parts. One part, highly mechanical, belongs to the system of goals -- a system too nearly complete in itself, too little connected with life itself. Stated psychologically, the danger is that learning will not transfer. Stated in terms of life, the danger is that a divided self -- that the child will look on learning as something to be learned and then put behind him."[1]

Although the Winnetka Plan is not without its defects, it is a great improvement over the traditional educational system, as scientific studies have revealed in many instances.

THE MORRISON PLAN

The Morrison Plan is a method of teaching which was developed by Henry C. Morrison, Professor of Education, University of Chicago, and is based upon his study of city school systems in New England and the Laboratory Schools of the University of Chicago.

Although this plan concerns itself chiefly with the improvement of instruction and has as its fundamental notions unit organization, the idea of mastery, and the development of techniques applicable to each subject in the curriculum, it is es-

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1. Kilpatrick, W.H., "An Effort at Appraisal", 24th Yearbook, National Society for the Study of Education, Part II, pp. 284,285.

sentially a plan of individual instruction.

Under this plan the subject-matter is organized into large units requiring perhaps twenty days or more to complete. Morrison defines the learning unit as follows:

"The learning unit is a comprehensive and significant aspect of the environment, of an organized science, of an art or of conduct, which being learned results in an adaptation in personality."[1]

This quotation as it stands may need a little explanation. By "comprehensive" Mr. Morrison implies that units should be relatively large subdivisions of subject-matter that corresponds to our traditional chapters of a textbook. Comprehensive in that the unit should embrace a great deal and relate it under one principle. By adaptation in personality Morrison means that an outcome results from learning activity or when the unit is mastered.

The unit consists of subdivisions that are called "elements". These elements are functional aspects in the understanding of the larger unit. The aspects must themselves be understood in relation to the unit and to one another.

Dr. H. B. Bruner of Teacher's College, Columbia University, gives the following steps which he considers helpful in writing up a unit:

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1. Morrison, Henry C., "The Practice of Teaching in the Secondary Schools, p.324.

1. "Determine what theme or themes are to control the unit.

2. "Select the assimilative materials by which big understanding are to be developed. This is the part of the unit marked 'Essential Meanings and Informational Materials to be Used in Developing the Main Understanding'. These materials should be selected in such a way that they bear directly upon the development of the understanding of the theme. The writer should be critical in his selection of materials, discarding that which is not pertinent, even if certain materials have been previously taught in this connection..... Write these in a logical outline, using an organization that seems most usable for the purpose. Include much more assimilative material than any one class will use but remember that it takes much interesting reinforcement to get over big understandings.

3. "Select the activities through which the assimilative materials may be acquired by the pupils. In addition to reading all the promising schemes for using the ideas and informations that are being suggested.

4. "Write the overview. This should be a general presentation of the point of view to be developed in the unit.

5. "Write the generalizations or small themes and the specific objectives. In anticipation of the teaching of the unit these cannot be recorded as definitely as actual outcomes. They should be brief and should be attainable from the standpoint of the materials included under content.

6. "Write the suggested approaches. These may or may not be used when the unit is taught as the teacher may want to use incidents or materials which develop with the class or are more recent than those suggested. They will indicate types, however.

7. "Decide upon possible teaching units captions which will indicate natural or interesting ways of breaking up the outline for teaching purposes.

8. "List possible problems that will suggest a more of attack from the standpoint of the pupil. These are particularly useful in gathering data and organizing it.

9. "Suggest a few culminating activities from which

the teacher may select one for use with the group for reassembling the materials after they have been studied separately. This affords an opportunity for pupil and teacher appraisement of the unit as a whole.

10. "List the outcomes which you consider essential. If desired, some informal tests may be added for the use of the teacher."[1]

Before working up a unit, however, the teacher gives a pretest. This is the first step in the teaching process termed "Exploration". The purpose of the pretest is that of finding out what the pupils know so that repetition will be avoided and time saved. It may also serve as a motivation.[2] It may in some instances disclose the fact that one or two pupils may be excused from presence in class during the learning process as applied to a particular unit. There are two other purposes for the pretest given by Morrison.[3] First, it orients the teacher and gives him ground for intelligent approach to the particular problem before him; and, second, it tends to establish in the minds of the pupils a connection between prospective learning and present attainments.

Ordinarily, the exploration will be finished in one

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1. Bruner, Dr. H. B., "The Place of Units in Course of Study Construction", Bulletin No.2 (1930), pp.20-21.

2. Monroe, Walter, "Directing Learning in the High School, p.98.

3. Morrison, Henry C., "The Practice of Teaching in the Secondary School", p.82.

day and the presentation of the unit will follow the next day. The presentation is the second stage of the teaching process. It is given orally by the teacher and is a motivation or overview. In brief, through direct, convincing oral presentation he teaches the unit.

The third instructional procedure is the assimilation. This may last for fifteen or sixteen days. During this period of time the pupil reads, studies, with only such assistance from the teacher as he may need. The assimilation period is the chief opportunity which the school affords for the development of pupils into students.[1] During the assimilation period the teacher does not sit by and do nothing. She assembles materials of study, gives pupils assistance when needed and puts the pupils in effective contact with their material.

Guide sheets play an important part during the assimilation period. The guide sheets contain instructions as to how to proceed on the unit, reference material, illustrations and series of problems focused upon the several elements in succession and upon the unit as a whole.

When the teacher is convinced that assimilation has taken place in the class as a whole, organization is announced.

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1. Morrison, Henry C., "The Practice of Teaching in the Secondary School", p.281.

The purpose of this organization is to gather up and organize the essential supporting facts in regard to the unit. The pupils come to class without books, notes or any other helps, begin to organize the material. The organization may take the form of a sylabus with headings which are to carry the argument, or an outline in systematic form of brief topic sentences. It is focused upon the central understanding and not upon the assimilative material. In form it is the outline of a coherent and logical argument and not merely an exhibit of facts.[1] Although during the assimilation period there is a great difference in the progress made by different pupils towards mastery, they are not allowed to take the organization as they come to it.

"Such a procedure simply results in a breakneck race through the school in which performance is exalted to the place of education. The notion of school work as being simply a series of tasks to be performed and belief in the brilliant student as the one who accomplishes such tasks most rapidly are both raised to the pinnacles of educational absurdity. Such pupils arrive at graduation point possessed of little but skill in accomplishing school work, infant prodigies who are promoted to higher institutions."[2]

The recitation is an eminently essential member of the learning and teaching cycle, and one of the essential features of the recitation is its social character. Usually three days

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1. Morrison, Henry C., "The Practice of Teaching in Secondary Schools", p.325.

2. Ibid, p.323.

are spent for this phase of the teaching procedure, although no definite amount of time need be set aside for it. The recitation under the Morrison Plan differs from the traditional recitation in that the teacher does not fire questions all through the recitation period. She guides and directs the recitation while the pupils engage in most of the activity. Points of view, which are valuable, are given by the pupils so that all may benefit from the learning activity and thus a more democratic feeling is produced, that of sharing knowledge and experience. Pupils may give special reports, illustrations and other useful material and information.

"The rapid learner not only should contribute his point of view which is likely to be valuable because of his extended study, but he should come into an attitude in which he can learn from others who are less brilliant but who have nevertheless something to contribute."[1]

After the recitation period is over and the instructor feels that he has taught the material sufficiently to the pupils to warrant mastery on their part, achievement tests are given. From the results of this test he diagnoses his own weakness and those of the pupils. If the pupils fail to master the material, the teacher adapts his procedure so that he will acquire the desired ends. The teacher reteaches the part of the unit in which the pupils failed, until they have ac-

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1. Morrison, Henry C., "The Practice of Teaching in Secondary Schools", p.324.

quired the piece of learning, or, as Morrison would state it, until they have mastered it. The technique employed by the teacher is called the "Morrison Mastery Formula":

"Pretest, teach, test the result, adapt procedure, teach and test again to the point of actual learning."[1]

The pupils who have mastered the unit do not start to work on the next unit. It is desirable to keep the class as a whole working together upon the same unit.

"Theoretically and ideally, whenever a pupil has learned, he should go on with his learning even though he be the only one in the section to do so. Practically, it does not work out that way."[2]

It not infrequently happens that a fast learner is not a sound learner, nor is the slow learner always a poor learner. Thus it is best to give those pupils who have mastered the unit extra work or a supplementary project in terms of differentiated assignments.

"Thus the superior pupil validates his superiority, not by rank in class, but by the acquisition of additional masteries."[3]

The assignment of extra work for the superior pupil is sometimes objected to. Some feel that it is not fair to the superior pupil, since it requires him to do more than others

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1. Morrison, Henry C., "The Practice of Teaching in Secondary Schools", p.81.

2. Ibid, p.87.

3. Ibid, p.91.

do. This objection is, of course, purely an instance of the performance stereotype at work and the commercial view of education. If education is a matter of contract between the pupil and the school in which the pupil does certain work in consideration of credits and ultimate diploma which the school covenants to award, then the objection holds. If education is conceived as a process of superior adjustment, then the supplementary project is a rare opportunity to the superior pupil.

Whether the pupil masters the subject may depend a great deal upon the technique used. Teachers too often blame the pupil for circumstances for which they themselves are the blame. It is easier to say that the pupil is dull, obstinate, lazy, and hopeless than to admit failure on the part of the teacher.

> "There is perhaps no single factor so commonly responsible for non-learning and perverted learning as persistent attempts to achieve a given learning product under the wrong type of technique."[1]

In considering the right techniques as important phases of learning, one cannot overlook the fact that great care must be taken in selecting materials to be mastered. Morrison feels that there is a great deal of non-teachable material in many of the textbooks. This material merely meets the requirement of ground to be covered, or the information theory of education.

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1. Morrison, Henry C., "The Practice of Teaching in the Secondary Schools", p.91.

The material is non-teachable because it bears no relation to the development of understandings, appreciation or abilities in the pupils.

"The common denominator of all non-teachable material is found in the principle that it either cannot be organized into units or is incapable of serving as assimilative material for units which might be organized."[1]

Dr. H. B. Bruner of Teacher's College, Columbia University, gives the following criteria for selecting content for the unit:

1. "The materials should be worth while in themselves. They should be significant to the pupil.

2. "Materials should be of interest to the pupils.

3. "Materials should be selected with due regard for the ability of pupils to understand and appreciate.

4. "Materials should be selected in terms of the available reading matter and must be on the reading level of the pupils. A course of study unit, however, should not exclude good materials simply because the schools are not then furnishing such materials.

5. "In choosing content give preference to that which offers richest opportunities for developing specific concepts other than those implied in the unit.

6. "In choosing content give preference to that which offers richest opportunity for establishing the right attitudes toward groups of people; achievements of people; science; social and physical laws; change; etc.

7. "In selecting materials of instruction avoid overlapping. Use content where it will do most good in fur-

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1. Morrison, Henry C., "The Practice of Teaching in the Secondary Schools" p.102.

thering the big understanding but avoid repetition except for purposes of illustration.

8. "In selecting content for the development of the themes one should consider completeness. Each item should have a function and while there is suggested more material than any teacher needs one should be careful that there are not omissions so serious that some significant aspect cannot be developed. A good rule is to select several items for doing the same thing in the development of the unit so that a teacher using the material may have a choice."[1]

The Morrison Plan of instruction seems to be adaptable to almost any type of school organization. Roy O. Billett in his survey of Secondary Schools using this plan received the following data in regard to the application of the Morrison Plan to different types of school organization:

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1. Bruner, Dr. H. B., "The Place of Units in Course of Study Construction", Bulletin No. 2, 1930, pp.13.

Table VIII[1]

Schools reporting the use of the Morrison Plan or the use of the Plan with estimated unusual success.

Type of Organization	Number of Schools Reporting	Schools Using the Plan		Schools using the Plan with estimated unusual success.	
		Number	Percent	Number	Percent
1	2	3	4	5	6
9 to 12	4,304	356	8	81	2
7 to 12	1,284	123	9	28	2
8 to 11	638	79	12	30	4
7 to 9	614	80	13	11	2
10 to 12	308	42	13	12	4
6 to 11	105	6	6	0	0
All Others	1,341	51	4	13	1
Total	8,495	737	9	175	2

1. National Survey of Secondary Education Bulletin, 1934, No. 17, Monograph #13, p.239.

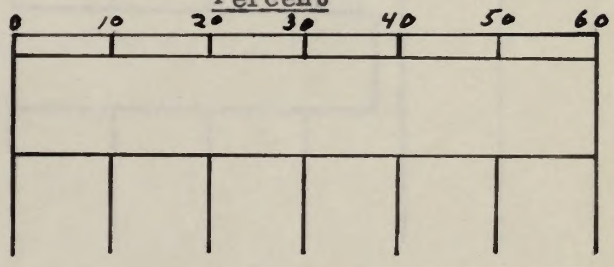
From Table VIII the following conclusions may be drawn: first, this plan seems to be adaptable to any type of school organization. Second, in schools including grades eight to eleven the plan is used more extensively than in schools including grades nine to twelve; and the respondents from the former schools are more inclined to estimate unusual success with this plan. Third, this plan is more extensively used than are the Dalton or Winnetka plans, for out of 8,594 schools reporting, 737 schools reported the use of this plan and 175 schools reported using this plan with estimated unusual success.

Another interesting feature brought out in the survey by Roy O. Billett is the extent to which various subject-matter fields were presented by means of the Morrison Plan:

Table IX[1]

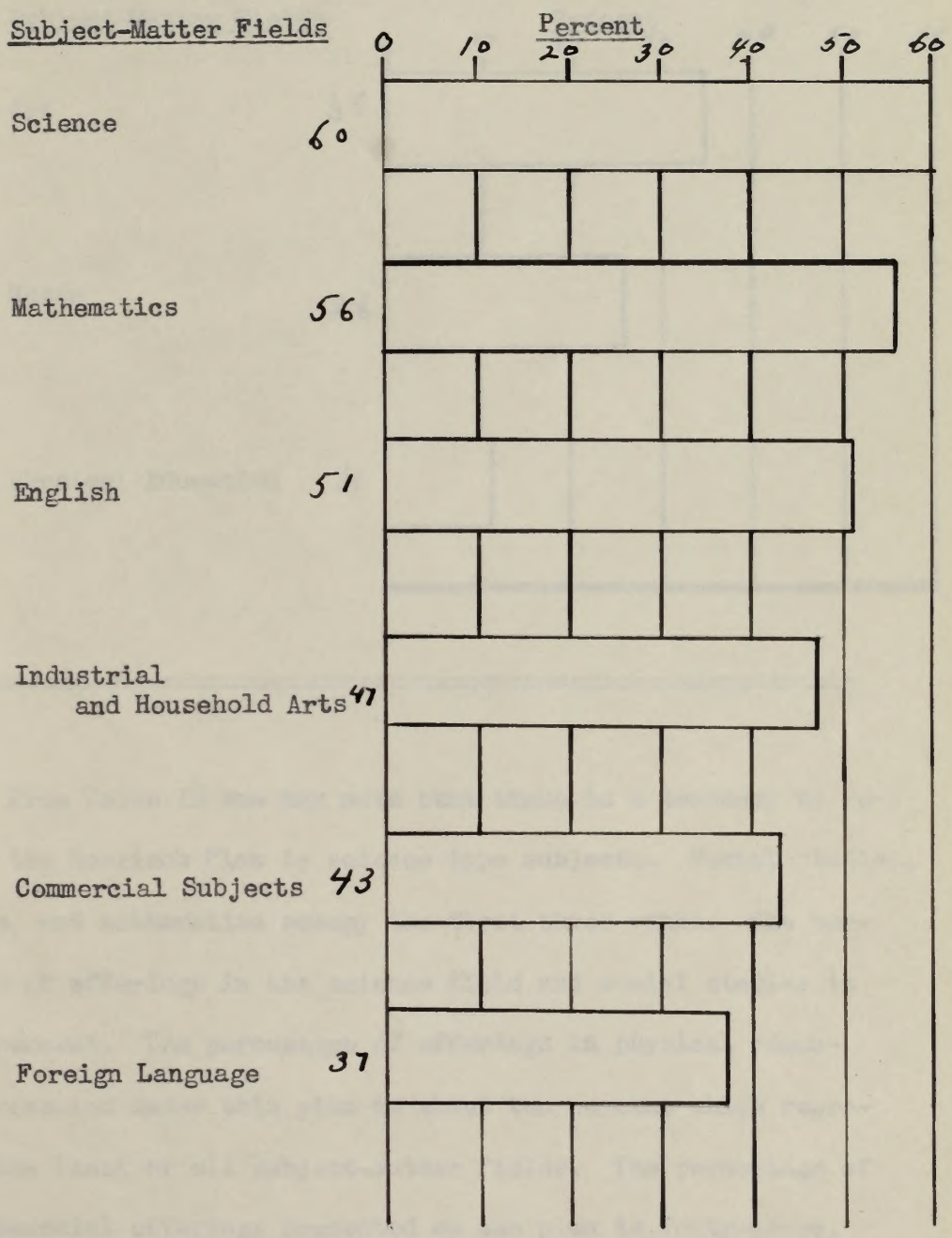
Percentage of offerings in each subject-matter field presented under the Morrison Plan.

Subject-Matter Fields	Percent
Social Studies	60



1. National Survey of Secondary Education, Bulletin No.17, Monograph No. 13, (1932), p.249.

Table IX (Continued)



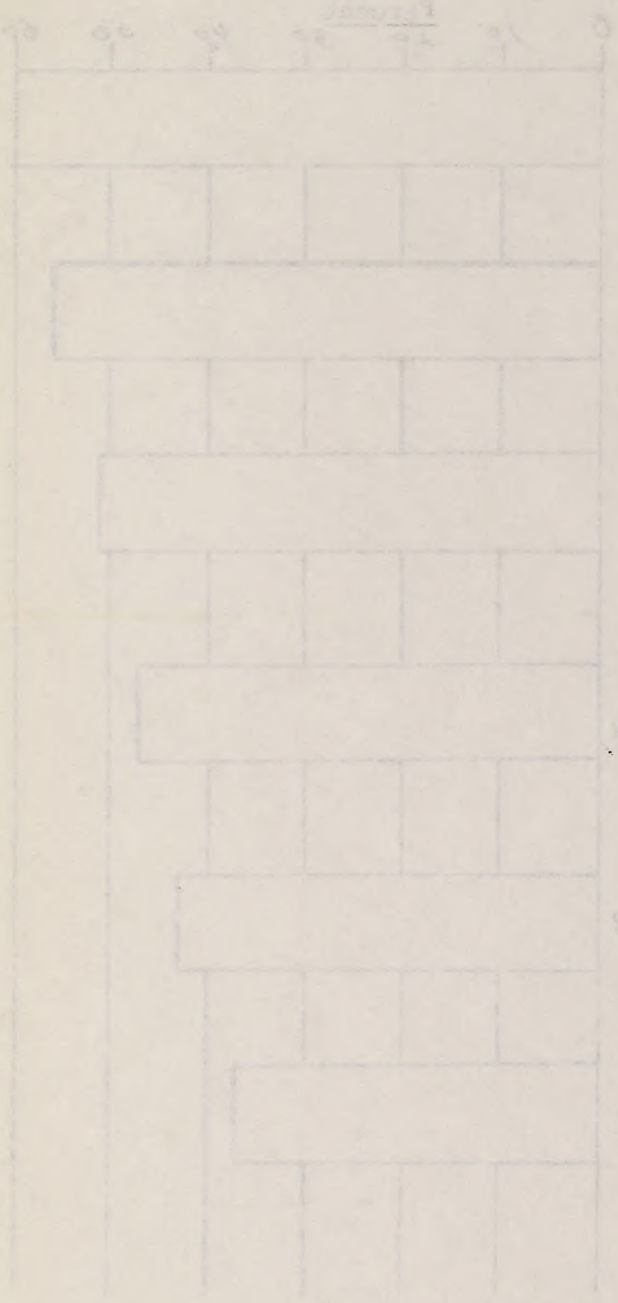
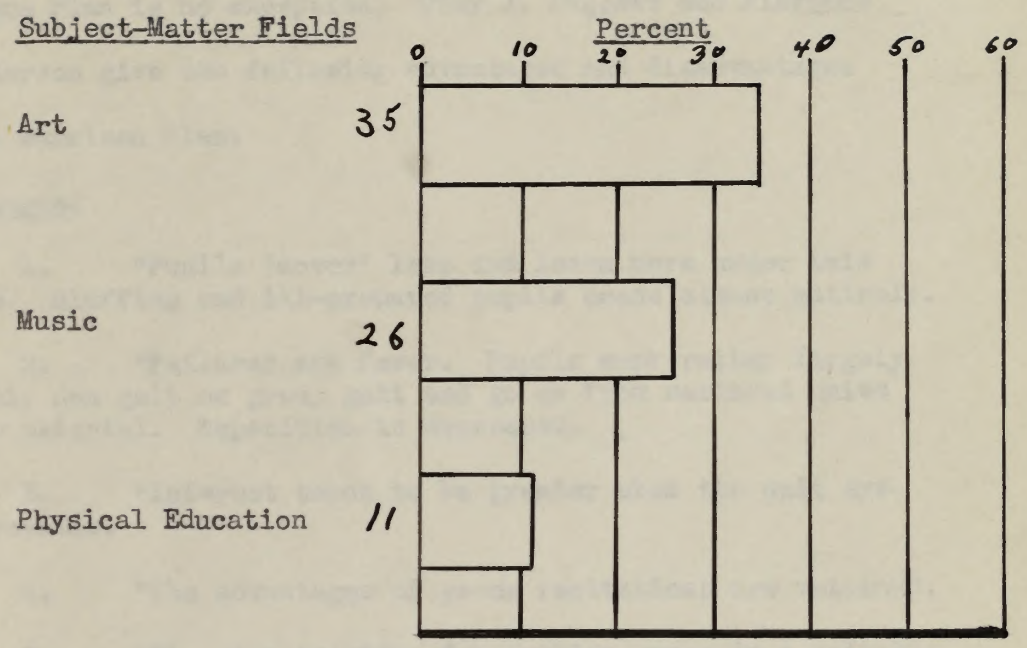
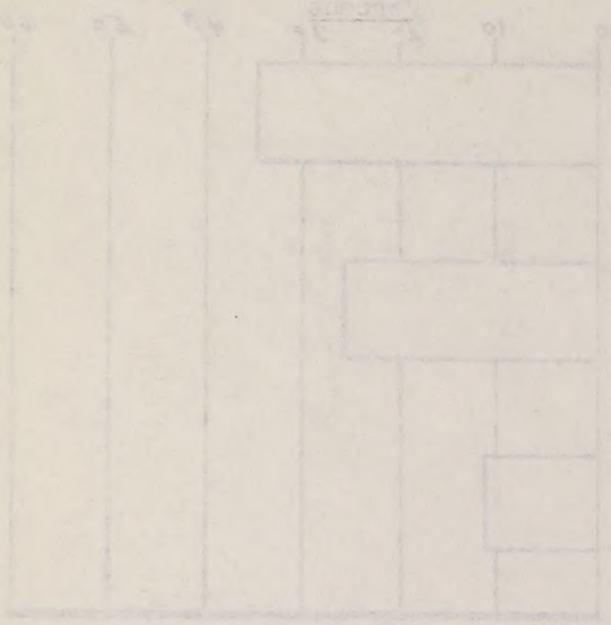


Table IX (Continued)



From Table IX one may note that there is a tendency to restrict the Morrison Plan to science type subjects. Social studies, science, and mathematics occupy the first three ranks. The percentage of offerings in the science field and social studies is sixty percent. The percentage of offerings in physical education presented under this plan is about ten percent which represents the least of all subject-matter fields. The percentage of all commercial offerings presented on the plan is forty-three, while foreign languages and art type subjects rank toward the bottom of the list.



Every plan has its advantages and disadvantages, the Morrison Plan is no exception. Clay J. Daggett and Florence A. Peterson give the following advantages and disadvantages of the Morrison Plan:

Advantages:

1. "Pupils 'cover' less and learn more under this system. Bluffing and ill-prepared pupils cease almost entirely.

2. "Failures are fewer. Pupils work rather largely at their own gait or group gait and go on from mastered units to new material. Repetition is decreased.

3. "Interest tends to be greater when the unit system prevails.

4. "The advantages of group recitations are retained.

5. "The plan provides for problem cases in a scientific manner.

6. "The school is made business-like and wise habits and attitudes are fostered.

7. "Techniques are developed to fit the particular subjects."[1]

Disadvantages:

1. "It is rather expensive. But product justifies increased expenditure.

2. "The burden placed upon the teacher.

3. "The marking system may not be comprehended by the average parent. He may, therefore, be antagonistic.

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1. Daggett, C.J. and Peterson, F.A., "Survey of Popular Plans for Instruction", Education Administration and Supervision, Vol. XVIII, (Sept., 1932), pp.500-501.

4. "The term mastery is ambiguous and vague. Morrison defines it as that extent of learning which results in an adaptation in personality. But certainly any degree of learning must result in some change in personality."[1]

The Morrison Plan is a relatively new plan, and it is significant in education because it attacks instruction from the teaching end, rather than from an administrative view.

The Dalton, Winnetka, and Morrison Plans are rather outstanding plans in education in that they break away from the traditional school procedure and no longer provide place for the hearing of lessons, where the pupils sit passively with arms folded, eyes front,memorizing textbooks, and reciting to the teacher, but in a genuine sense a laboratory where the pupils are actively assimilating experiences under direction of the teacher.

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1. Daggett, C.J. and Peterson, F.A., "Survey of Popular Plans for Instruction", Education Administration and Supervision, Vol. XVIII, (Sept., 1932), pp.500-501.

CHAPTER IV

A Sample Unit in Chemistry

CHAPTER IV

A Sample Unit in Chemistry.

The writer is going to attempt to work out a unit in chemistry, based on the Morrison technique. The writer selected the Morrison Plan for his procedure in working out a unit of work on "Coal, Diamonds, and Other Forms of Carbon", because the Morrison Unit Plan is adaptable to the present classroom organization, whereas the Dalton Laboratory Plan and the Winnetka Plan require a complete reorganization of present classroom organization and administration.

Unit I

Coal, Diamonds and Other Forms of Carbon

Preview

For the next two weeks we are going to study about carbon and its oxides. The word "carbon" is more or less familiar to everyone. It suggests coal and smoke and troubles with automobile engines. In cities, especially, it annoys us by soiling our clothes. Not many persons, however, realize this soft substance which is so useful as a fuel has also its decorative value, for it is the same substance that composes the very hard, brilliant gem prized for centuries and known as the diamond.

There are two oxides of carbon about which we are going to study, Carbon Dioxide and Carbon Monoxide. Carbon Dioxide is used commercially in the manufacture of beverages and "dry ice", and a various number of other things. Carbon Monoxide has very few uses. It is a very poisonous gas. It has no odor and gives no warning of its presence. Many deaths result each year from the escape of this gas into the air of rooms and factories, thus rendering the air poisonous. The exhaust gases of automobile engines contain 4 to 12 percent carbon monoxide, so that running an automobile engine in a closed garage is a very dangerous act.

Pretest

1. Give six uses of amorphous carbon.

2. What property of carbon makes it useful in a gas mask?

3. Name two different uses for diamonds.

4. Whenever carbon is burned in air or in oxygen at ordinary temperature, carbon dioxide is formed. Write the equation for the reaction.

5. Write the equation for the reaction that will take place if carbon dioxide comes in contact with very hot carbon.

6. Which oxide of carbon is very poisonous? What would you do if you found someone overcome by this poisonous gas?

7. Name one substance that you eat containing carbon.

8. Explain what is meant when we say that coke is prepared by the destructive distillation of coal.

9. What is the composition of the so-called lead pencil?

10. Why is carbon useful in reducing ores?

Guide Sheet

Coal, Diamonds and Other Forms of Carbon.

Directions

1. The "C" assignment is to be completed before beginning assignment "B" or "A".

2. Do all written work in your notebooks.

3. You will not find all the material you need in your textbook. Consult other chemistry books when necessary.

4. Read all about carbon and the two oxides of carbon in your textbook before working out the unit.

5. Be sure and look up in the dictionary all the new words you come across in your readings.

6. This unit is to be completed in two weeks.

Assignment "C"

1. Prepare a comparison of fuels, using a tabular form containing the headings: Kinds of Fuel; Approximate Composition; Advantages; Disadvantages.

2. Explain why fence posts are sometimes charred at the end before being placed in the ground.

3. How would you recognize a natural diamond, if one were found in the midst of some gravel?

4. Why is graphite used in: (a) lead pencils; (b) lubricants; (c) crucibles for melting metal; (d) electrodes for electric furnaces.

5. Answer the following questions in reference to carbon dioxide:

(a) By what other name is it known?

(b) Name three natural sources of the gas.

(c) Account for the fact that it can be poured from one vessel into another like water.

(d) What property of the gas is utilized in making soda water?

(e) Name the chemicals used in the preparation of the gas in the laboratory, and write the equation for their reaction with each other.

6. Calculate from the formula CO_2 the approximate weight of 1 liter of carbon dioxide.

7. Name the possible sources of danger of being poisoned by carbon monoxide.

8. Why are not people in danger from carbon monoxide when the streets of the city are crowded with automobiles?

9. Calculate how many liters of carbon dioxide, at standard conditions, can be obtained by treating 45 grams of pure marble with acid.

Experiment I

To show whether some common substances contain carbon.

1. Put into a test tube a little roll of paper, pushing it well down into the closed end of the tube. Apply heat. Does air easily come in contact with the paper while it is being heated? Continue heating until smoke ceases. Let the test tube cool. Dislodge the contents and examine them. Describe the appearance.

2. Repeat 1, using a piece of dry wood, such as a piece of match stick, or splint, in place of paper. Describe the residue. What is it?

3. Repeat 1, using a bit of starch or a cereal in place of the paper. Describe the residue.

4. Repeat 1, using a bit of a vegetable. Describe the residue.

5. Repeat 1, using a bit of meat. Describe the residue.

6. Repeat 1, using a bit of cotton batting. Describe the residue.

7. Repeat 1, using a bit of wool. Describe the residue.

8. What color is the residue in each case? What is the residue?

Experiment II

To determine the effect of bone black on some colored organic substances.

1. Fill a test tube to the depth of one inch with bone black. Add about 10 cc. dilute cochineal or litmus solution. Mix thoroughly and let it stand for several hours or overnight. Fold a filter paper, adjust it to a funnel, then pour the bone black and the cochineal or litmus mixture into the funnel. Catch the filtrate in a test tube. Compare the color of the filtrate with that of the original solution. What caused the change in color?

2. Repeat 1, using a solution of brown sugar or corn syrup instead of the cochineal or litmus solution. Compare the filtrate with the original solution. What caused the change in color?

Experiment III

To prepare carbon dioxide and note some of its properties.

1. Arrange an ordinary bottle with a stopper, funnel tube,

and delivery tube of rubber tubing. (This is the same apparatus as in generating hydrogen. See Experiment I, Unit I.) Put some lumps of marble into the bottle, cover with water, and adjust the stopper in the mouth of the bottle. Add enough hydrochloric acid to produce a steady evolution of gas. Describe the appearance of the liquid when action begins.

2. Collect 2 bottles of the gas by displacement of water. Is the gas very soluble in water? How do you know?

3. Complete and balance the equation for the action occurring between marble and the acid.

$$CaCO_3 + HCl \qquad CaCl_2 + H_2O + ?$$

4. Plunge a lighted splinter into one of the bottles of gas. What happens?

5. Pour a little limewater into the second bottle of gas. Cover and shake it. What is the result?

6. Write a numbered list of the properties and chemical conduct of carbon dioxide which you have observed in this experiment.

Assignment "B"

1. Explain the use of charcoal in the gas mask.

2. Draw a diagram of an electric furnace and show how graphite is produced in such a furnace.

3. Design a "carbon tree" in which the trunk is carbon, the main limbs are the different forms of carbon, and products formed by their combustion are the secondary limbs.

4. What is done in the Holland Tunnels when the registering instrument shows an increase in the amount of carbon monoxide in the tunnels?

5. Explain what happens to the body when carbon monoxide is breathed.

Assignment "A"

1. Visit your fire department and find out all you can about the fire apparatus called "chemical", such as (a) the materials used in charging and the weight of each used; (b) how the apparatus is recharged after a fire; (c) the cost of the materials used in charging; (d) chemical reactions when in operation.

2. Build and exhibit to the class. Make a model of a furnace for making graphite. The following is listed as suggested material, since it is easily secured: empty chalk box; two crayons; pieces of coal; core of a lead pencil; sand.

3. What is meant when we say that two atoms "share electrons"? Make a diagram to represent such a case.

4. Where would you suggest putting the exhaust pipe of the automobile?

5. On a general average, a person exhales about 8 liters of air per minute, containing approximately 4 percent by volume of carbon dioxide. Suppose there were 100 students in a schoolroom, and that there was no ventilation. How many liters of carbon dioxide would be added to the air of the room each hour?

Organization

Coal, Diamonds and Other Forms of Carbon.

I. Crystalline Carbon

A. Diamonds

(1) Diamonds are found in a pure white state and also in colors. Even black diamonds are known. The diamond is the hardest substance known.

(2) Diamonds are used as abrasives as well as gems.

B. Graphite

(1) Graphite occurs in the form of flat, hexagonal crystal scales. They are soft and slippery, so that graphite serves well as a lubricant for special uses.

(2) Graphite can be made artificially in an electric furnace.

(3) Graphite is used in making lead pencils, in making crucibles for melting metals, and for electrodes in electric furnaces.

II. Amorphous Carbon

A. Coal is valuable as a fuel because of the carbon it contains. In all varieties of coal the carbon is chiefly present in the uncombined form, but there are also some hydrocarbons. All coal also contains ash.

(1) Anthracite, or hard coal, is the form in which decomposition has proceeded farthest. It contains much uncombined carbon, little hydrocarbon, and ash.

(2) Bituminous, or soft coal, contains 20% or more volatile matter, chiefly hydrocarbons; the remainder consists mainly of uncombined carbon and ash.

(3) Coke results from destructive distillation of soft coal. Chemically it resembles hard coal.

B. Charcoal, made by the destructive distillation of wood, burns without much flame or smoke and is used in gas masks and filters.

C. Boneblack is made by the destructive distillation of bone. It is used as a filtering material to decolorize sugar and oils.

D. Lampblack is made by cooling sooty flames. It is used for black paint and for printers' ink.

III. Carbon Dioxide.

A. Carbon dioxide is an important part of the food of plants; chlorophyll bodies in leaves, with the aid of the energy from sunlight, cause carbon dioxide to unite with water, forming starch and oxygen.

B. Carbon dioxide is best made in the laboratory by reactions between a carbonate and dilute hydrochloric acid.

C. Carbon dioxide can be liquified by pressure at ordinary temperatures. It is also on the market as a solid, known as "dry ice", which makes a good refrigerating agent.

D. The test for carbon dioxide is made by bringing the gas into contact with a solution of calcium hydroxide; a white precipitate of calcium carbonate results.

IV. Carbon Monoxide.

A. Carbon monoxide is a colorless, odorless gas, insoluble in water and weighs about the same as air.

B. Carbon monoxide is a deadly poison because of its action on the hemoglofin of the blood.

C. Carbon monoxide is given off from automobiles. Special ventilation of tunnels and garages is therefore necessary.

D. Carbon monoxide is a good deoxidizing agent.

Test

1. By what experiment would you prove that diamonds consist of nothing but carbon?

2. State the differences between graphite and diamond; between graphite and amorphous carbon.

3. By what means are different degrees of hardness obtained in making lead pencils?

4. How is charcoal made? Name important use of charcoal.

5. Write three equations that illustrate the action of carbon at high temperatures.

6. By what process may carbon monoxide be obtained from carbon dioxide? Account for the explosions that frequently occur in coal stoves shortly after coal is added. State how these explosions may be avoided.

7. Explain how cases of asphyxiation occur in a closed garage in which an automobile engine is running.

8. Write the equations for the reactions which take place in a carbon dioxide fire extinguisher.

9. What problems had to be solved in building long tunnels for automobile traffic?

10. How many liters of carbon monoxide can be obtained by deoxidizing 20 liters of carbon dioxide by carbon?

SUMMARY and CONCLUSIONS

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Summary

There is a great deal of evidence for a need for individual instruction in chemistry in that chemistry courses do not attract a homogeneous group of pupils in regard to their mental capacities. In fact, a very wide range of differences may be found. The I.Q.'s of pupils taking chemistry range from 68 to 172. Although there is a tendency to place pupils of low mentality into the Industrial Cooperative Chemistry, the range in I.Q.'s still remains so great that any attempt at group instruction could not be justified. The recitation or group method of instruction is generally acknowledged to be inefficient because (1) it sets the same pace for all pupils in the class, a pace too slow for the more clever and too fast for the more stupid; (2) it wastes the time of those who know the lesson and teaches little to those who do not; (3) it does not give to the teacher an accurate knowledge of the progress made by the bashful or slow pupil and brings in undesirable personal elements. The Dalton Laboratory Plan, the Winnetka Plan, and the Morrison Plan do away with these disadvantages that are inherent in the recitation.

The three plans are similar in that they are based on the unit assignment. They differ in regard to classroom organization.

The Dalton and Winnetka Plans call for a complete reorganization of the classroom. The Morrison Plan, however, does not require a complete reorganization of the school. A teacher may use the Morrison Plan without interfering with the traditional classroom organization.

Conclusions of Study

1. There is a wide range in individual differences in high school pupils taking chemistry.

2. Individual instruction is one method of overcoming the problem of individual differences.

3. All subjects may be taught by this method.

4. Individual instruction should be combined with some class work for successful teaching.

5. The number of advantages gained under individual instruction outnumber the disadvantages.

6. The Morrison Plan seems to be the best adapted to different school systems in that it stresses teaching methods rather than administrative methods.

7. Individual instruction does not cost more than class instruction.

8. Chemistry classes do not represent a selective group of pupils.

9. The writer suggests that teachers who desire to replace the traditional recitation by individual instruction and not interfere with administrative methods, use the Morrison Plan, as it is adapted to any classroom organization.

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